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Witness:	James A. Merciel, Jr.
Sponsoring Party:	MO PSC Staff
Type of Exhibit:	Rebuttal Testimony
Case Nos.:	SR-2013-0321 and WR-2013-0322
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MISSOURI PUBLIC SERVICE COMMISSION

REGULATORY REVIEW DIVISION

REBUTTAL TESTIMONY

OF

JAMES A. MERCIEL, JR.

LINCOLN COUNTY SEWER & WATER, LLC

CASE NOS. SR-2013-0321 and WR-2013-0322

Jefferson City, Missouri
September 2013

BEFORE THE PUBLIC SERVICE COMMISSION

OF THE STATE OF MISSOURI

In the Matter of the Application of Lincoln County Sewer and Water, LLC for Approval of a Rate Increase	)))	Case No. SR-2013-0321
In the Matter of the Application of Lincoln County Sewer and Water, LLC for Approval of a Rate Increase	)))	Case No. WR-2013-0322

AFFIDAVIT OF JAMES A. MERCIEL, JR.

STATE OF MISSOURI)
) ss
COUNTY OF COLE)

James A. Merciel, Jr., of lawful age, on his oath states: that he has participated in the preparation of the foregoing Rebuttal Testimony, in question and answer form, consisting of 26 pages and 5 Attachments, to be presented in the above case; that the answers in the foregoing Rebuttal Testimony were given by him, that he has knowledge of the matters set forth in such answers; and that such answers are true to the best of his knowledge and belief.

James A. Merciel, Jr.

Subscribed and sworn to before me this 24th day of September 2013.

Notary Public

LAURA BLOCH
Notary Public - Notary Seal
State of Missouri
Commissioned for Cole County
My Commission Expires: June 21, 2015
Commission Number: 11203914

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<u>Table of Contents</u>

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LINCOLN COUNTY SEWER & WATER, LLC

CASE NOS. SR-2013-0321 and WR-2013-0322

INTRODUCTION

Q. Please state your name and business address.

A. James A. Merciel, Jr., P. O. Box 360, Jefferson City, Missouri, 65102.

Q. By whom are you employed and in what capacity?

A. I am employed by the Missouri Public Service Commission ("Commission") as a Utility Regulatory Engineering Supervisor, in the Water and Sewer Unit.

Q. Please describe your education and work experience.

A. I graduated from the University of Missouri at Rolla in 1976 with a Bachelor of Science degree in Civil Engineering. I am a Registered Professional Engineer in the State of Missouri. I worked for a construction company in 1976 as an engineer and surveyor, and have worked for the Commission in the Water and Sewer Unit since 1977.

Q. What are your work responsibilities at the Commission?

A. My responsibilities include reviewing information and making recommendations with regard to certifications for new water and sewer utilities, sales of utility systems, formal complaint cases, and technical issues associated with water and sewer utility rate cases. In addition to formal case work, I handle informal customer complaints that are of a technical nature, conduct inspections and evaluations of water and sewer utility systems, and informally assist water and sewer utility companies with respect to day-to-day operations, planning, and customer service issues. In the past, I have supervised engineers and technicians in the Water and Sewer Unit working on the above-described type of case work and informal matters. In the context of my position with Staff, I served on the American Water Works Association Small Systems Committee for three years, and have served on the National Association of Regulatory Utility Commissioners Staff Subcommittee on Water for approximately the past seventeen (17) years.

Q. Have you testified before the Commission previously?

A. Yes. A list of cases in which I have provided testimony is included as Schedule JAM 1 to this Rebuttal Testimony.

PURPOSE OF TESTIMONY

Q. What is the purpose of your Rebuttal Testimony?

A. The purpose of this Rebuttal Testimony is to respond to the Direct Testimony of Dale Johansen. Specifically, this Rebuttal Testimony will support the Staff's "capacity adjustments" made to certain components of Lincoln County Sewer & Water, LLC's ("LCSW") utility plant-in-service level, will explain Staff's position regarding Mr. Johansen's testimony on the bookkeeping and depreciation treatment of disallowed plant, and will offer comments on LCSW's use of "remote read" water meters.

CAPACITY ADJUSTMENTS - GENERAL

Q. Please describe, generally, what is meant by capacity adjustment?

A. A capacity adjustment reduces, or disallows, part of the capital investment of one or more plant items from the rate calculation, usually because there is substantially more plant capacity and correspondingly more investment than what is reasonably needed to provide service to current ratepayers.

Q. Besides recommending a capacity adjustment for LCSW in this case, does Staff recommend capacity adjustments to utility plant for other regulated utilities?

A. Yes, Staff frequently recommends capacity adjustments for other utilities.

Q. Can you please briefly describe why capacity adjustments are used?

A. Yes. Capacity adjustments could be applied when any utility constructs plant or plant additions, perhaps for future growth, at a level that is considered to be a much greater than necessary for the current demand. But also, especially for water and sewer utilities, capacity adjustments are often applied to systems that serve areas where new development is taking place. The reason for this can be illustrated by considering a new utility system that is designed for some appropriate customer level, say 300 lots. The utility system needs to be constructed before any customers exist at all, but rates would need to be set for some customer level which may or may not represent full system capacity. The utility will not realize its full earnings and expense recovery from ordinary revenue until that customer level is attained. In other words, one or two customers cannot be expected to pay for capital recovery and expenses associated with a system designed to serve 300 customers. There are thus inherent disallowances until the pre-determined customer level is attained.

Q. Is there any formula or other standard that the Staff uses to determine capacity adjustments?

A. No, there is not any one standard for capacity adjustment that can be applied to all situations. The above example of a new 300 lot subdivision is one simple example, but there are variables involved with real situations, and it is necessary to study each situation and make some case-by-case judgments. One potential variable could be whether or not the utility is solely responsible for the utility system, versus whether or not a subdivision developer is involved and is available to risk investment for the subdivision venture. Another variable is whether or not the utility is a new operation that is starting with zero customers and planning to expand to the 300 customer level, or if the utility already has perhaps several thousand customers and intends to expand to several thousand plus the 300. And, there could be additional subdivision development projects besides the one subdivision, which additional development may or may not be integrated together into one system. The utility's business planning, investment risk, the potential impact upon customers' rates, and benefit to customers resulting from company investment all could be completely different for these scenarios.

Q. Is a disallowance that is related to capacity adjustment the same thing as a disallowance of an investment that is held for future use?

A. No, it is not the same thing. Plant held for future use would be an item that exists, but is not being used. The item may or may not be depreciating in value. Examples could include: a parcel of real estate that is kept for future construction; an item that is kept in protective storage to be used in the future or maybe replace a similar item; or a vacant structure that could be used for something at a later time, when it will be treated as an item placed into service. All of these items would become "used and useful" only after they are finally used to provide service to customers. On the other hand, a capacity adjustment is applied to an item that is "used and useful," meaning it is actually in use and providing service to customers, its useful life is in progress and it is depreciating in value; but it is larger and costs more than is reasonably necessary to provide service to the utility's existing customers. The full value of the item and related expenses would appear on the utility's financial records, but some portion of that full value simply is excluded for calculating rates.

Q. Did Staff apply capacity adjustments to LCSW's plant levels in LCSW's CCN case, WA-2012-0018?

A. Yes.

Q. Can you please describe the capacity adjustments made by Staff in WA-2012-0018?

A. Yes. In that case, Staff identified three (3) utility plant items that it considered to be larger than necessary in order to serve existing customers. The three items are the water storage tank, the submersible well pump/motor unit (sometimes referred to simply as a well pump), and the sewage treatment facility, that are provide service to customers in LCSW's Rockport subdivision service area, one of its two service areas. It is clear that the Rockport water and sewer systems both were constructed with the intent to serve a much larger customer level than reflected by the then-current level of sixty-two (62) customers in Rockport. The two phases of the Rockport subdivision, according to what LCSW filed in its application in that case, had 210 lots with homes being constructed to a limited extent; but there was also a substantial amount of undeveloped land within the service area that LCSW had requested. Staff took the position in the CCN case that if these capacity adjustments were not applied, the existing customers would overpay in rates for the excessive capital cost related to overbuilding of certain components of the Rockport water and sewer systems in anticipation of future growth. Staff decided in that particular case to recommend no adjustments to other components of the utility facilities such as structures, fencing and real estate, because these other items were fully used without regard to customer usage and growth. Staff made no capacity adjustments to any plant items in LCSW's other service area, the Bennington subdivision.

CAPACITY ADJUSTMENTS - STAFF RECOMMENDATION

Q. What is Staff proposing for capacity adjustments for this current case?

A. For this current case, Staff is using the same methodologies as were applied in the CCN case, updated for customer growth. Staff did not use updated water use numbers although water usage appears to have decreased somewhat, likely due to the use of water meters. Use of the decreased water usage for a capacity calculation would actually increase the capacity adjustment disallowance even though there has been customer growth; and making a recommendation with this result is not sensible. A worksheet for the calculations are included with this Rebuttal Testimony as Schedule JAM-2, and incorporated herein by reference.

Q. How does Staff calculate its capacity adjustments, beginning with the storage tank?

A. Staff's adjustment to the cost of the storage tank, a standpipe, was made in consideration of the design principle of providing a one-day storage volume for single-well system operations. Storage tanks generally serve a purpose of supplementing well production during peak hourly flow that occurs at certain times each day, but in addition to this purpose the one-day level of stored volume would be available for customers in the event of a failure of the well pump, providing a sufficient volume of water for customers during replacement of the pump which is approximately a day-long task. The usable volume of the standpipe is conservatively estimated to be 44,000 gallons which is approximately one-third of total volume. There is unusable volume in a standpipe because the water elevation provides system water pressure, and when the water level falls below the usable volume level then system water pressure would be too low for some customers. Staff assumed a normal average daily use of approximately 180 gallons per day per customer in the CCN case that was based on master meter readings at the time from the wellheads of primarily the Bennington well but also limited data available from the Rockport well. The current level of seventy-two (72) customers, up from sixty-two (62) in the CCN case, would use approximately 12,960 gallons in a one-day period, or approximately 29.5% of the available tank volume. For this current case, Staff applied a 70% disallowance of the tank cost. This is less than the 75% disallowance Staff and the Company agreed to in the CCN case.

Q. Do you have an estimated customer level to illustrate the capacity of the storage tank with respect to the current 72 customer level?

A. Yes. My estimate is the storage tank has capacity to serve 244 customers using the 180 gallons per day water use number and other assumptions for single-well operation. Further, if LCSW were to construct a second well for this subdivision or interconnect with another system, then this storage tank would only be necessary for peak flows instead of a one-day supply. Recent production data as indicated by LCSW's master meter records show that peak day could be more like 400 gallons per customer instead of 600 gallons as was assumed in the CCN case. If this indication of actual usage is realistic, then the tank capacity for multiple-well operation would be approximately 440 customers using a "default" design criterion of tank volume for domestic flow of 25% of peak day flow.

Q. How does Staff calculate its capacity adjustment for the submersible well pump/motor?

A. Staff's adjustment to the well pump/motor is made in consideration of its pumping capacity of 420 gallons per minute as observed by Staff, and a desired maximum run time of fourteen (14) hours per day, a criterion assumed by Staff for conservative well operation. This total volume of water is 352,800 gallons and is the amount needed to meet customer demand for one day at maximum daily usage, which is "peak day" usage. An assumed peak day usage of 600 gallons per customer, which could occur on extreme days with lots of outdoor water use such as lawn sprinkling, would result in total daily usage of 43,200 gallons for the existing 72 customers, which is approximately 12.2% of pump capacity. <u>For this current case, Staff applied a 87% disallowance to the cost of the well pump. This is reduced from the 90% disallowance Staff and the Company agreed to in the CCN case.</u>

Q. Do you have an estimated customer level to illustrate the capacity of the well pump with respect to the current 72 customer level?

A. Yes. My estimate is this well pump unit has capacity to serve <u>588 customers</u> using this estimated peak day flow number of 600 gallons and the other assumptions. But if actual peak day usage were 400 gallons per customer, as described above for the storage tank capacity, then the capacity would be approximately <u>882 customers</u> imposing the same fourteen (14) hour run time per day. For purposes of the recommended disallowance in this case, I would not consider capacity of this well pump to be significantly different if this well were operated along with a second well.

Q. How does Staff calculate its capacity adjustment for the sewage treatment facility?

A. Staff's adjustment to the cost of the sewage treatment facility was made in consideration of the discharge permit issued by DNR. The plant capacity as stated on the permit is 78,000 gallons per day; and, an "adjusted design flow," to reflect current usage at present as stated on the permit, is 14,999 gallons per day. This adjusted sewage flow amount is approximately 19.2% of the facility design flow, which reflects slightly more than what

Staff estimated to be the water usage of the existing customers in the CCN case. Starting with this calculation based on the discharge permit at the time of the CCN case, and updating for the increase to the current 72 customer level, <u>for this case, Staff applied a 77% disallowance of the treatment facility. This is reduced from the 80% disallowance Staff and the Company agreed to in the CCN case..</u>

Q. Do you have an estimated customer level to illustrate the capacity of the sewage treatment facility with respect to the current 72 customer level?

A. Yes. My estimate is this sewage treatment facility has capacity to serve <u>322 customers</u> if the CCN case customer level of 62 and the permit flow level of 14,999 gallons per day are used. This would be a per-customer daily use of approximately 242 gallons which is, as stated, more than what water production data indicates.

Q. How are these capacity adjustments to the three utility system components applied to monthly rates?

A. The percentages are used by Lisa Hanneken of the Staff Auditing Unit to calculate the capacity adjustment amounts to plant in service, which appear in Staff's Accounting Schedules. Following this, the costs associated with rate base including a return on investment and depreciation expense are included among the expenses, and used in rate design.

SUMMARY OF STAFF POSITION

Q. Could you please summarize your position on capacity adjustments?

A. Capacity adjustments should be made in many circumstances where there is substantially more capital investment, perhaps for future growth, than is needed for current customers, especially when there are alternatives to determining size of utility plant components, or when there is investment risk that really belongs with a developer, or both. There are combinations of circumstances that require judgment in determining whether or not capacity adjustments should be made and how to make them. Staff takes the position that LCSW's Rockport water and sewer systems include components that may be reasonable for future development but are substantially oversized for present use, and present customers should not bear the risk of such investment in capacity that is not needed today. As it did in LCSW's CCN case, Staff takes the position that if capacity adjustments are not applied, the existing customers would overpay in rates for the excessive capital cost related to overbuilding of certain components of the Rockport water and sewer systems in anticipation of future growth. Staff recommends capacity adjustments in this current case that are calculated the same way as were applied in the CCN case, updating for Rockport customer growth, and that the capacity adjustments are reasonable with respect to customer rates, and utility operations notwithstanding investment that may exist for the benefit of investors and future customers as future growth occurs.

RESPONSE TO TESTIMONY OF DALE W. JOHANSEN

Q. Have you reviewed the Direct Testimony filed by Dale W. Johansen?

A. Yes.

Q. Do you disagree with any of the points Mr. Johansen makes in his testimony?

A. Yes. I have two reasons why I disagree with Mr. Johansen's testimony regarding Staff's recommended disallowance for well pump capacity. I also disagree with some of the numbers and assumptions Mr. Johansen uses for his assessment of Staff's recommended disallowances for the water storage tank capacity and for the sewage treatment facility capacity. And, I disagree with Mr. Johansen's proposed treatment of Staff's plant disallowances as "plant held for future use," and related depreciation treatment.

WELL PUMP

Q. What are the two reasons that you disagree with Mr. Johansen's assessment of Staff's well pump capacity disallowance?

A. The first reason is Mr. Johansen's interpretation of DNR's approval for operation of the Rockport water system pertaining to whether one or two wells are utilized. The second reason is the customer water useage, both from design considerations and actual useage, as related to how many customers could be served using this well, whether or not another well is utilized.

Included with this Rebuttal Testimony as Schedule JAM-3 and incorporated herein by reference is a copy of DNR's *Reports on Plans and Specification of a New Water System* (DNR Report) dated December 27, 2007 and pertaining to the Rockport Subdivision. This document was included with LCSW's *Application* that created Case No. WA-2012-0018, the CCN case, as Appendix 6A. Also included with this Rebuttal Testimony as Schedule JAM-4 and incorporated herein by reference is a copy of DNR's *Design Guide for Community Water Systems* (Water Design Guide). Some of the information used as a basis for each of these reasons for disagreement may be found in the Water Design Guide, which is a publication DNR makes available. I have marked on both documents to highlight information I find particularly relevant.

Q. Can you please briefly explain DNR's approval of operation of the water system as stated in the DNR Report?

A. Yes. The DNR Report specifies that approval of the water system is valid for 120 lots in Phase I of the development, but also states that approval of the water system contemplates an additional 90 lots in a future Phase II, for a total of 210 lots. It states that prior to serving any lots in Phase II, a second well will be required, along with DNR review and approval of such future plans.

Q. What is your disagreement with Mr. Johansen with regard to the DNR Report and the operation of one well versus two wells?

A. Mr. Johansen states on page 13 Line 15 of his Direct Testimony that the capacity of the well pump should be set at 120 customers. His reasoning appears to be that the DNR Report validates use of the existing well for 120 customers, and that a second well is needed for what he apparently considers additional capacity to serve another 90 customers, resulting in two wells with combined capacity to serve 210 lots. However, designing the water system by adding the production capacities of the two wells together to serve 210 lots in this manner is not correct. On page 28 of the Water Design Guide in section 3.2.1.2., titled "Number of Sources," paragraphs a., b. and c. each state that for multiple well operations adequate capacity to meet maximum day volume shall be met with the largest producing well out of service. This means that either of two wells serving the 210 lots as contemplated in the DNR Report, and not both operating together, would be needed for adequate capacity to serve all 210 lots. The second well is for reliability, not for needed additional capacity. Either well, then, would provide adequate production capacity while the other is out of service. So, with regard to my first reason for disagreement with Mr. Johansen, as per the DNR Report in context with the Water Design Guide specification for multiple well operation, the existing well is really approved in the DNR Report for providing service to 210 lots, not 120 as stated in his testimony. If the existing well really only had capacity for 120 lots, then the water system, if serving more than 120 customers, as a whole would have inadequate capacity even with a second well in service.

Q. Does the DNR Report set a limit, or state any maximum, of how many customers the existing well may serve?

A. No, the DNR Report does not set any such limitation, and does not state any maximum capacity of 120 lots nor of 210 lots. The DNR Report approves use of the well for this stated development project; to 120 lots, and then to 210 lots if another well is placed into service. That does not mean the well cannot have or does not actually have more capacity than what is needed for these lots, nor does it mean that it could not be approved for use with further expansion of the water system beyond the requested Rockport Phase I and Phase II plan, with appropriate further DNR approval. Or in other words, a larger-than-necessary well and well pump would meet, or actually exceed, the requirements DNR imposed for approval of a water system for Rockport Phases I and II.

Q. Do you have any observation and comment with respect to the requirement for a second well to be constructed for Phase II?

A. Yes. Referring again to Page 28 of the Water Design Guide, in the same section 3.2.1.2. referenced above, paragraph b. states that water systems serving 500 or more persons shall utilize more than one well (with adequate system capacity to serve customers with the largest well out of service). Since residential customers in a utility service area typically are households averaging between 3 and 4 persons, the 500 person level would be expected to be attained sometime after most of the 120 lots of Phase I are occupied, and before Phase II is built out. So, DNR having imposed the requirement of a second well before occupancy of homes in Rockport Phase II is consistent with this specification of the Water Design Guide about a requirement for multiple wells for reliability. The requirement does not reflect a need for more capacity beyond that of the existing well for Phase II.

Q. On Page 13 beginning on Line 10 of his testimony, Mr. Johansen points out that using Staff's disallowance methodology, LCSW could be required to construct a second well even while LCSW is not being allowed full recovery of the existing well in rates, for capacity reasons – could this situation occur as he states?

A. Yes, absolutely this situation could occur, and in fact could very likely occur as more home construction occurs in Rockport, depending on future changes to factors that could affect a Staff position on capacity disallowance.

Q. Would you consider this to be placing LCSW in an unusual situation?

A. No I would not. It is no different of a situation than disallowing capacity recovery while this water system is operated as a single-well system.

Q. Why not?

A. The heart of this reasoning is the purpose of the second well. A second well is not for additional capacity, and this situation would not be one where some cost of one well is disallowed for capacity reasons when an additional well is being required for more capacity. If this were the situation, then a disallowance would indeed not be logical nor reasonable. Rather, the purpose of the second well is for reliability, so that adequate capacity exists while one well is out of service for whatever reason, as per the Water Design Guide in 3.2.1.2b. As such, a second well may indeed be required by DNR consistent with the Water Design Guide regarding when multiple wells must be used; but even with a second well the existing well could still have much more capacity than is needed, and so Staff could still recommend a capacity disallowance.

Q. What is your disagreement with Mr. Johansen with regard to the production capacity of the well as it exists and customer water usage?

A. My disagreement is, very simply and as discussed earlier in this Rebuttal Testimony, the existing well has capacity that far exceeds not only the needs of existing rate-payer customers but also beyond the 120 customer level that Mr. Johansen proposes and beyond the 210 customer level from the DNR Report. My calculation of capacity as related to a customer level, as described above, is 588 customers, and that results from an assumption of a maximum day use of 600 gallons per customer, and a Staff-imposed maximum well pump run time of 14 hours, both assumptions being conservative so as to not over-disallow expenses and thereby unreasonably limit LCSW's ability to recover capital expenses, but still place some reasonable limit on what existing customers should be paying.

Q. Does the Water Design Guide address needed production capacity?

A. Yes, it does. It is found in section 1.1.2. entitled "Extent of the water system(s)." There are various "default" values for water use. For rural water systems the default is 60 gallons per day per person, and if 3 persons per house were assumed then the result would be 180 gallons per day, the same value Staff estimated using observed master meter readings in the CCN case. Multiplying this number by 150% would be 270 gallons per day, whereas Staff conservatively (for the disallowance calculation) assumed a maximum day use of 600 gallons per day. Of course, a design engineer has some freedom to estimate water use values that are based on actual use within a water system that already exists, or estimate based on usage of similar water systems, and also include other reasons for estimating water usage. Calculations using other default usage values by assuming greater water use per person as the Water Design Guide suggests for municipal residential customers, by including lawn irrigation use, and by assuming greater than 3 persons per house would result in greater usage per customer, but I do not believe those other assumptions and adjustments are applicable for this situation and Staff's disallowance.

Q. What is your conclusion with respect to Mr. Johansen's testimony, the capacity of the well pump, and Staff's proposed well pump disallowance?

A. I consider Staff's estimate of 180 gallons per customer per day, based on observed production data that was available in the CCN case, to be both realistic and consistent with what the Water Design Guide suggests. Using this water use number, and considering observed production of 420 gallons per minute and the Staff-imposed time limit of 14 hours pump run time per day as a conservative measure, results in a capacity to serve 588 customers and is the basis of Staff's disallowance. Mr. Johansen uses 120 customers, which is only based on the DNR approval of one of the two particular subdivision phases, and by water design principles and DNR's Water Design Guide is not a correct number to use. Mr. Johansen's recommendation does not take into consideration capacity that actually exists, and is not realistic with respect to the cost of needed capacity to provide service. Staff's disallowance is fairer to the ratepayers, and also allows LCSW to recover additional capital expense as customer growth occurs and more capacity is utilized.

STORAGE TANK

Q. What is your disagreement with Mr. Johansen regarding disallowance associated with LCSW's Rockport storage tank facility?

A. My disagreement is whether actual customer water use and tank volume that is usable for water storage with adequate pressure for all customers should be used to calculate capacity, as Staff did in the CCN case and recommends in this case, versus Mr. Johansen's proposal to simply apply a customer level number that is based on the DNR Report without regard to actual tank capacity.

Q. Would you please briefly explain the use of water storage tanks?

A. Yes. Storage tanks are used for several purposes that can include the following:

1. They can serve as a supplement to the source of supply (well) production, providing a volume of water during peak flow times of the day such as first thing in the morning when people shower and have breakfast, as well as early evening when people have supper and do home activities that use water. The well is then able to replenish storage overnight, mid-morning, and mid-afternoon when there is not much water usage.
2. They can also contain a reserve water supply for use if the source of supply such as a single-well is out of service because of damage or for maintenance.
3. They contain water at or above an elevation level that can maintain constant working water pressure for the water system. Since water is not compressible, most electric pumps, if used to pump directly into a distribution piping system without some type of tank, would result in large and frequent fluctuations in pressure, frequent starting and stopping which is inefficient use of power and adds wear to electric motors, and inefficient use of power since the flow the pump is expected to produce would not be constant;

4. Finally, storage tanks can hold a reserve water volume that can be used for fire protection, flushing the water system, or other legitimate uses of water that might require flows that are greater than flow produced by a well pump.

Q. Is the Rockport standpipe used for all of these activities?

A. At this time it is not used for fire protection. It is used or is available to be used for all of the other stated purposes.

Q. How is a necessary tank size determined?

A. The Water Design Guide may be used in determining needed tank volume, on pages 139, 140 and 141 in Section 7.1., entitled “Tanks and Reservoirs for Finished Water Storage.” For its recommended tank disallowance for Rockport as a single-well system, Staff is applying section 7.1.2.a. which specifies usable tank volume to be a one-day supply.

Q. What is Staff’s specific calculation for the Rockport tank capacity?

A. The dimensions of the tank are shown on the DNR Report. There would be a vent and an overflow pipe near the top, and the tank would not actually completely fill with water. As noted earlier in this testimony, and as noted in the Water Design Guide, there is an unusable volume of water in a standpipe. Exactly what the unusable volume is could be subject to study but could be at approximately the 50 foot elevation, which is as about half of the volume. Water at an elevation would produce approximately 20.6 pounds per square inch (PSI) water pressure. However to take into consideration pressure loss during high flow and that some homes could be at a slightly higher elevation than the tank, Staff conservatively assumed 44,000 gallons, approximately one-third of the tank volume, to be usable. As also noted earlier in this testimony, using the average per-customer daily usage of 180, this is adequate capacity as a one-day supply for 244 customers as a one-day tank volume.

Q. What is your conclusion with respect to Mr. Johansen's testimony, the capacity of the storage tank, and Staff's proposed tank disallowance?

A. Although Staff's evaluation and calculations use a different methodology than Mr. Johansen's use of the permit number, the difference in the result is not that great, at 244 customers versus 209 customers, and as Mr. Johansen correctly noted the disallowance amounts are Staff's 70% versus 65.55%. However, I stand by Staff's recommendation, because it is based on realistic water use values and a calculation of actual tank capacity using conservative criteria.

SEWAGE TREATMEMT FACILITY

Q. What is your disagreement with Mr. Johansen regarding disallowance associated with LCSW's Rockport sewage treatment facility?

A. My disagreement is whether the disallowance should be based on some actual observed flow as Staff did in the CCN case and recommends in this case, versus Mr. Johansen's proposal to simply apply a customer level number that is based on the DNR Report without regard to actual use of plant capacity.

Q. Can you briefly explain how sewage treatment capacity is utilized by customers?

A. Yes. As customers use water, most of that same water is discharged into the sanitary sewer along with organic and chemical waste, ultimately arriving at the treatment facility for processing, then discharge to a stream. Outdoor water use such as lawn and garden irrigation and washing cars however is not included as sewage discharge. The sanitary sewer also sometimes picks up some additional water as infiltration and inflow, mostly during rain events. The strength of the waste water, sometimes expressed as "biochemical oxygen demand" or BOD, can be variable depending upon the types of customers to be connected to the system, and such strength needs to be taken into consideration when designing a treatment facility. Unlike other items such as a well pump or an electric generator that produces some commodity with a firm maximum limitation (i.e. x gallons per minute or y kilowatts), a sewage treatment facility must process waste that is sent to it, using bacteria for biochemical breakdown along with mechanical removal of solids. Several types of sewage treatment facilities are available to be used with central sewer systems as well as by individual homeowners, with variations on how the process is carried out, but any plant must be able to allow adequate time for the biological treatment to occur and for solids settling. To do that, the plant is designed so that hydraulic flow through the various plant chambers at a specified maximum rate of flow would provide the amount of time that is normally needed for the biological processing the waste load, and thus treatment facility capacity is most often expressed in gallons per day.

Q. What type of treatment facility is in use for Rockport, and how does the facility work?

A. The Rockport treatment facility is what is called an "extended aeration" treatment plant. The way it fundamentally works is sewage water flows continuously through an aeration chamber where air is introduced using blowers and submerged air diffusers, where most of the bacteriological breakdown occurs. The volume of the aeration chamber provides for approximately one-day detention. Then, from the aeration chamber the sewage water flows through a clarifier where solids settling occurs. The clarifier would have a dimension for the water surface of perhaps one square foot per 1,000 gallons per day, or some other number based on type of treatment and actual settlability of the solids, along with other specifications including depth. Solids must be removed periodically from the clarifier, an activity commonly called "sludge hauling."

Q. Is there a guide that may be used for sewer system design?

A. Yes, DNR incorporates a design guide for sewer systems in its regulations. It may be found in 10 CSR 20 Chapter 8. A copy of DNR's regulation is included with this Rebuttal Testimony and incorporated herein by reference as Schedule JAM-5, and referred to herein as the "Sewer Design Guide."

Q. What part of the Sewer Design Guide is applicable to the capacity of the Rockport treatment facility?

A. Default flow and organic values may be found at 10 CSR 20-8.140(5)(C) 1. and 2., on page 44 of the Sewer Design Guide. The default value for flow is 100 gallons per day per person and 370 gallons per day per customer; however similar to water system design other justifiable flow rates may be used.

Q. What is the capacity of the Rockport treatment facility?

A. The Rockport treatment facility has a total flow capacity of 78,000 gallons per day. However, it is constructed in three (3) separate units, each with capacity of 26,000 gallons per day. At present, one of the three units is being utilized, the other two are not in use yet.

Q. Can you please re-state Staff's position regarding disallowance with respect to the sewage treatment facility?

A. Yes. In the CCN case, Staff considered several alternative methods that included calculations based on actual water use of 180 per customer per day which would result in the greatest disallowance; or based on what is termed the actual flow as stated on the

DNR permit for this facility, 14,999 gallons per day, or disallowing two-thirds of the cost based on the fact that only one of three units was actually in operation. Staff based its disallowance on the DNR permit flow number because it was the middle option, and Staff considered it to be the most reasonable of the options. By this methodology, customer water use related to sewage flow would be 242 gallons per customer for a residential customer capacity of 322 customers. Staff, in this current case, is continuing to recommend disallowance based on this methodology but has reduced the recommended disallowance to reflect customer growth, from 62 in the CCN case to the 72 customer level used in this case, for a disallowance of 77%.

Q. How does this compare to Mr. Johansen's recommendation?

A. Mr. Johansen's recommended disallowance is based on the 210 customer-level as stated in the DNR Report, similar to his recommendation on the water storage tank. He uses a 209 customer-level design capacity to arrive at a disallowance of 65.55%. This is very close to the 66.67% that would result if the disallowance were based on one of three units in operation but my two primary concerns with this methodology are: 1) it assumes that the default Sewer Design Guide water usage is applicable to this operation, which if that assumption were valid would mean that the one unit is operating at slightly over capacity at 26,640 gallons per day for 72 customers, with a design capacity of 26,000 gallons per day; and 2) the 65.55% disallowance would include a portion of the units that are in fact not in operation.

Q. What is your conclusion with respect to Mr. Johansen's testimony, the capacity of the sewage treatment facility, and Staff's proposed sewage treatment facility disallowance?

A. Staff's evaluation and calculations use a different methodology than Mr. Johansen's use of the permit number, resulting in a difference in the recommendations that is based on 244 customers versus 209 customers, resulting in Staff's 77% versus Mr. Johansen's 65.55%. However, I stand by Staff's recommendation, because it is based on flow as expressed in a DNR permit, and is conservative with regard to actual customer water use.

PLANT HELD FOR FUTURE USE

Q. What is your disagreement with Mr. Johansen regarding treating the disallowance amounts as plant held for future use?

A. In his Direct Testimony on page15 lines 3 through 6, Mr. Johansen positively asserts that Staff identified the disallowances as "plant held for future use" in the CCN case. Staff does not recommend recording the disallowance on LCSW's books in this manner. Mr. Johansen also asserts that depreciation of the item, or portion of the item, should begin when the plant is finally placed into service.

Q. Can you please explain the disagreement with respect to recording the disallowances on LCSW's books?

A. Staff does not consider the disallowances to be held for future use, as discussed earlier in this Rebuttal Testimony. As discussed, the disallowances particularly the well pump and the storage tank are each single items that are in service (used and useful) but are larger than necessary at present. The disallowances are simply exclusions from rate calculations, and do not indicate that Staff considers any portion of those items as not in service yet. Staff's treatment of these disallowances is consistent with the Uniform System of Accounts, or USOA which, generally in its various versions, is a system of accounts that regulated utilities are required to use to maintain books and records. The USOA specifies in its definitions for plant held for future use that normal spare capacity of plant in service shall not be included in the account for plant held for future use.

Q. What is the disagreement with respect to depreciation?

A. Contrary to Mr. Johansen's statements, depreciation of the disallowed portions of the plant items is occurring, because the items are used and useful in their entirety, are wearing, and are depreciating in value as the service life is used. However, again and as discussed earlier in this Rebuttal Testimony, depreciation expense attributable to the disallowed plant is not included in rates. It would not be proper depreciation treatment to wait until some later time to begin depreciation of a portion of an item when it is in fact depreciating today, even though some such expense is excluded from rates because of capacity. However in accordance with the USOA the items would be subject to depreciation, proper recording of depreciation, but depreciation would not necessarily be included in today's rate calculations.

Q. Can you please summarize Staff's disagreements with regard to LCSW's plant held for future use issue?

A. Yes. Staff does not agree that the disallowances are plant held for future use, because the items are used and useful, in service and are depreciating. Staff does not agree that depreciation on disallowed portions of plant, or plant held for future use, should be deferred.

REMOTE READ WATER METERS

Q. Mr. Johansen, on page 4 line 16 of his Direct Testimony, discusses some advantages of the meters that LCSW utilizes for its customers – do you agree with Mr. Johansen's comments?

A. Yes, although the cost of the water meters that can be read remotely by radio from a vehicle, along with related equipment and computer software, could be a factor in determining reasonableness, I generally agree with the points Mr. Johansen makes, including the fact that some benefits are intangible or not quantifiable. In addition to his points about the capability of this system to be able to acquire and keep records pertaining to water usage detail, the remote reading capability can also be a time-saving tool available to the utility in managing its obligation to read every water meter each billing period.

SUMMARY OF TESTIMONY

Q. Could you please summarize this Rebuttal Testimony?

A. Yes. Staff recommends capacity disallowances of LCSW's Rockport well pump, storage tank, and sewage treatment facility, which are based on the same methodologies as those used in the LCSW's CCN case, which methodologies are based on customer water usage and sewage flow as was determined in the CCN case, but adjusted for customer growth. Staff strongly disagrees with Mr. Johansen's recommendation regarding the well pump capacity disallowance, because: 1) the methodology is not consistent with water facility design principles nor the DNR Water Design Guide; and, 2) the well pump is much larger than what is reasonably required, under any water usage guides or usage assumptions, to serve the existing customer level and even the DNR Report-approved customer level of 210 customers. Staff disagrees with Mr. Johansen's recommendations for storage tank and sewage treatment facility disallowances, because, although his results are within what could be deemed a reasonable range, they are not based on actual customer usage of capacities, as are Staff's recommendations. Also, because of the principles specified in the USOA, Staff strongly disagrees with Mr. Johansen's proposal that disallowed plant be treated as plant held for future use, and also his proposal to defer depreciation of the disallowed portion of plant items. Finally, Staff agrees with Mr. Johansen that remote read water meters can provide benefits, some intangible, with regard to utility operations and customer service.

Q. Does this conclude your Rebuttal Testimony?

A. Yes.

SR-2013-0321 and WR-2013-0322
Cases with Testimony by James A. Merciel, Jr. (not all inclusive)
September 2013

Algonquin Water Resources
    WR-2006-0425
Aqua Missouri, Inc.
    SC-2007-0044
Big Island – Folsom Ridge
    WO-2007-0277
Bill Gold Investments, Inc.
    WC-93-276 (11/5/93) – Receivership case
Blue Lagoon, LLC
    SO-2008-0358
Camelot Utility Co.
    WA-89-1
Capital City Water Co.
    WR-94-297
    WR-90-118
    WO-89-76 – plant capacity study
    WR-88-215
    WR-83-165.
Davis Water Company
    WC-87-125 and WC-88-288 - quality of service, lack of needed upgrades
    Along with a proceeding in the Circuit Court in Wayne County approx 1988
Environmental Utilities, LLC
    WA-2002-65 (11/2001) Certificate case
Finley Valley Water Company / Public Funding Corporation, City of Ozark
    WM-95-423
Gascony Water Company, Inc.
    WA-97-510
House Springs Sewer Co.
    SC-2008-0409
Lake Region Water and Sewer Co.
    SR-2010-0110 and WR-2010-0111
Lake Saint Louis Sewer Co.
    SR-78-142
    SA-78-147 - expansion of service area
    SC-78-257 - The Nine-Twelve Investment Co., et al Oak Bluff Preserve vs. Lake Saint Louis Sewer co, regarding method of providing service.
    SO-81-55 and Circuit Court in St. Charles County - alleged improper disconnection of service along with injuction., approx 1980 or 1981
Merriam Woods Water Company
    WC-91-18 and WC-91-268 – quality of service
Mill Creek Sewer System, Inc.
    Proceeding by MO Attorney General in Circuit court in St. Louis County, Cause No. 611261, 1998 DNR water pollution violations

Schedule JAM-1

Miller County Water Authority
- WC-95-252 and Circuit Court in Camden County approx 1995 - Complaint by Staff regarding operating without a certificate

Missouri American Water Company
- SA-2012-0066 (Saddlebrooke)
- WR-2011-0337
- WR-2008-0311 and SR-2008-0312
- WR-2007-0216
- WC-2006-0345 - Dione C. Joyner, Complainant (service line maintenance)
- WR-2003-0500
- WR-2000-281
- WR-97-237/SR-97-206
- WT-97-227 / WA-97-45 / WC-96-441 - Complaint by Water District 2 regarding customers outside service area, and service area expansion
- WA-97-46 – certificate case for St. Joseph wellfield
- WR-95-205
- WR-95-174
- WR-93-212
- WR-91-211
- WR-89-265
- WR-87-177
- WR-85-16

Missouri Cities Water Company
- WR-95-172/SR-95-173
- WR-92-207
- Proceeding in Circuit Court in Audrain County, CV192-40SCC approx 1992 city of Mexico attempted condemation of water system
- WR-91-172/SR-91-174
- WR-90-236
- WR-89-178/SR-89-179
- WC-88-280 – William J. Fox d/b/a Fox Plumbing vs MO Cities, service line/main extension matter
- WR-86-111/SR-86-112
- WC-86-20 – Mexico Doctor's park, main extension
- WR-85-157
- WR-84-51
- WR-83-15/SR-83-14

North Oak Sewer District, Inc.
- SR-2004-0306

Osage Water Co.
- WA-99-256 (8/5/99) - Lakeview Beach certificate case
- WC-2003-0134 (10/31/02) - Receivership case

Raytown Water Company
- WR-92-85 / WR-92-88
- WR-94-211

Southwest Village Water Company
- WO-89-187 – quality of service
- WC-89-138 (included testimony in Circuit Court in Greene County 1989)

St. Louis County Sewer Co.
- SC-83-255 – complaints about stormwater inflow/infiltration

St. Louis County Water Company
- WR-97-382
- WR-96-263
- WR-95-145
- WR-94-166
- WR-93-204
- WR-91-361
- WR-88-5
- WR-87-2
- WR-85-243
- WC-84-29 – Dewey Eberhardt vs St. Louis County Water Co., fire protection
- WR-83-264
- WR-82-249
- WC-79-251-Natural Bridge Development Corp vs. St. Louis County Water Co., meter accuracy/testing

Stoddard County Sewer Co.
- SO-2008-0289 – receivership, transfer, etc.

Suburban Water and Sewer Co.
- Injunction hearing, Circuit Court in Boone County 07BA-CV02632, June 2007
- WC-2007-0452
- WC-84-19 – service issues

United Water Missouri
- WR-99-326

Villa Park Heights Water Co.
- WA-86-58

Warren County Water and Sewer Co. -
- Circuit court case in Warren County CV597-134CC, September1997 dispute with homeowners over a lot proposed to be a tank site
- WC-2002-155 / SC-2002-260 - March 2002 Receivership case filed by the Office of the Public Counsel

West Elm Place Corporation
- Circuit court lawsuit case in Jefferson County, approx 1988 Customer's lawsuit for damage from sewage backup

Rockport disallowance — SR-2013-0321 and WR-2013-0322
September 2013 — Merciel rebuttal

all revisions truncated to whole percentage number

Water System

water plant disallowances using original values of 180 gallons per customer per day ave use, and 600 gallons per customer peak day

	Tank useful volume	44,000	gallons	244 customers
	Pumping capacity	420	gpm	588 customers
revised	customers	72	from 62 customers in ccn	

Tank disallowance calculated using average day reserve (for single well operation)

revised for customer level using original 180 gallons per day per customer

revised system average day	12,960		
percentage tank vol	29.5%	**revised disallowance 70%**	from 75% in ccn case
	244 customer capacity		

Well pump disallowance calculated using 600 gallon peak day per customer (actual value unknown)
(pump/motor cost only, no labor, no well construction)

runtime of 14 hours — 352,800 gallons per day capacity

revised for customer level using original 600 gallons peak day

revised system peak day	43,200		
percentage	12.2%	**revised disallowance 87%**	from 90% in ccn case
	588 customer capacity		

Sewer System

sewer plant disallowance based on DNR permit adjusted flow

Treatment facility	78,000	gallons per day (DNR permit)	322 customers
	14,999	permit-stated actual flow	

Treatment facility disallowance
revised for customer level using 14,999 gal for 62 customers - 242 gallons per customer

revised flow	17,424.00		
% of capacity	22.3%	**revised disallowance 77%**	from 80% in ccn case
	322 customer capacity		

ROCKPORT WELL

DEPARTMENT OF NATURAL RESOURCES OF MISSOURI
REPORTS ON PLANS AND SPECIFICATIONS OF A NEW WATER SYSTEM

Rockport Subdivision
Troy, Missouri
Review No. 62374-06

December 27, 2007

INTRODUCTION:

A final inspection of the new water supply serving Rockport Subdivision, Troy, Missouri, was conducted by Mr. James J. Hessel II of the Department of Natural Resources.

Plans and specifications were submitted for review and approval by Fitch & Associates, Consulting Engineers, Troy, Missouri.

BRIEF DESCRIPTION:

In general, these plans and specifications provide for a new water system consisting of a well, standpipe, and distribution piping.

This approval is only valid for 120 lots in Phase I of the development.

The well is located in the SW ¼, Section 13, T48N, R1W, Lincoln County. The well was drilled to a total depth of 1,490 feet and provided with 550 feet of 8-inch diameter casing. The annular space between the drill hole and the casing was filled with neat cement grout from the bottom upward in one continuous operation. A submersible pump having a capacity of 385 gallons per minute at 600 feet of TDH was installed. The well was provided with the necessary depth gauge, valves, discharge piping and other appurtenances as per detailed plans and specifications. The well was disinfected and samples were collected for bacteriological and chemical analyses.

The standpipe is located at the well site and is 15 feet in diameter by 110 feet in height with a capacity of 145,000 gallons. The standpipe was provided with the necessary air vent, overflow pipe, roof hatch, manway, valves, fittings and appurtenances as per detailed plans and specifications. The tank was painted, disinfected, and sampled for bacteriological analyses.

The distribution piping consists of approximately 10,500 lineal feet of 8-inch, 6-inch, and 4-inch Class 200 PVC pipe along with the necessary valves, fitting and appurtenances. The distribution system was disinfected and samples were collected for bacteriological analyses.

COMMENTS:

1. Prior to relinquishing continuing operating authority to the Rockport Subdivision Homeowner's Association, the department must be contacted so that a change in ownership of the system can be documented. This will allow the department to observe the condition of the system and also ensure that the homeowners' are made aware of the responsibilities that go along with owning, operating, and maintaining a water system. Until such time, the developer will be the continuing operating authority and will be responsible for all technical, managerial, and financial issues associated with the community water system.

2. The engineering report stated that the entire development will consist of 210 lots where Phase I will consist of 120 lots and Phase II the remaining 90 lots. Prior to serving Phase II, a second well will need to be drilled. The department will need to review and approve the plans and specifications at that time.

CONCLUSION:

The facility has been constructed in essentially the configuration approved and the equipment provided is as specified by the approved plans. This inspection is not a certification that the project and/or its component equipment will perform as represented by the engineer or the various equipment manufacturers or parts suppliers.

Should you have any questions regarding this report, please contact Mr. James J. Hessel II at the Department of Natural Resources, St. Louis Regional Office at 314-416-2960.

Inspected by:

James J. Hessel II
Environmental Specialist II
St. Louis Regional Office

Approved by:

Dan Daughtery
Drinking Water Unit Chief
St. Louis Regional Office

JJH/DJD/jh

FINAL APPROVAL

The completed water supply facilities described above were examined as to features of construction which may affect the operation of the facilities, including size, capacities of various units, and features which may affect the efficiency and ease of operation. The completed facilities, so far as could be determined, are constructed essentially in accordance with the approved plans, and final approval of the completed project is hereby granted.

In the final inspection of the facilities, the Department of Natural Resources does not examine structural features or the efficiency of mechanical equipment. This final approval does not include approval of these features. This inspection is not a certification that the project and/or its component equipment will perform as represented by the engineer, or the various equipment manufacturers or parts suppliers.

The Department reserves the right to withdraw the approval of the water supply facilities at anytime they are found to be operating unsatisfactorily, and to require alterations, additional treatment or changed methods of operation as deemed necessary to place the facilities in satisfactory condition.

MO 780-1234 (8-90)

Design Guide for Community Water Systems

Effective August 29, 2003

Missouri Department of Natural Resources
Public Drinking Water Program
P.O. Box 176
Jefferson City, MO 65102-0176

Printed on Recycled Paper

PUB000417

PSC STAFF HIGHLIGHTS:

Water system volume requirements - Section 1.1.2 Page 2

Single/multiple well operation; production capacity - Section 3.2.1 Page 28

Tank size - Section 7.1 Page 139

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TABLE OF CONTENTS

Schedule JAM-4

Tables

DEFINITION OF TERMS

The following is a list of terms used throughout this document and the definition of each.

Average Day Demand-- The amount of water used in an average day. Calculated by dividing the total annual water production by the number of days in the year.

Comprehensive Performance Evaluation (CPE)-- A systematic review and analysis of a water treatment plant's performance without major capital improvements. It is the first part of a composite correction program.

Continuing Operating Authority -- The permanent organization, entity or person identified on the permit to dispense water who is responsible for the management, operation, replacement, maintenance and modernization of the public water system in compliance with the Missouri safe drinking water statutes and regulations (see definition in 10 CSR 60-3.020).

Design Instantaneous Peak Flow -- The flow rate measured at the instant the maximum demand is occurring in a water system. It is calculated by dividing the cross-sectional area of the water pipe by the velocity of the water at any one instant.

Design Average Day Demand -- The anticipated amount of water used in an average day. Calculated by dividing the anticipated total annual water production by the number of days in the year.

Design Maximum Day's Demand -- The anticipated amount of water needed to satisfy the day of highest water usage. Typically, this is 150% of the Average Day Demand.

Design Period -- The span of time any proposed water system or water system component will be utilized.

Diurnal Flow Pattern -- A plot of water demand versus time for a 24-hour period. The curve depicts a typical period of time and is used to simulate the daily operation of the network, especially the cycling of system storage.

Fire Protection -- The ability to provide water through a distribution system for fighting fires in addition to meeting the normal demands for water usage.

Historical Data -- Actual records of past water production, consumption, and other operational information.

Maximum Day Demand --The amount of water needed to satisfy the day of highest water usage. Typically, this is 150% of the Average Day Demand.

Maximum Flow -- The greatest amount of water demanded within a specified time period.

Maximum Hour Demand -- The amount of water needed to satisfy the highest flow rate in a water system occurring for a one-hour duration.

Peak Demand -- The maximum momentary load, expressed as a rate, placed on a water treatment plant, distribution system, or pumping station. It is usually the maximum average load in one hour or less, but may be specified as instantaneous or for some other short time period.

Peak Flow -- See Maximum flow.

Period of Record -- The time span covered by a particular set of data.

GLOSSARY

ANSI	American National Standards Institute
API	American Petroleum Institute
ASTM	American Society for Testing and Materials
AWWA	American Water Works Association
CFR	Code of Federal Regulations
CPE	Comprehensive Performance Evaluation
CSR	Code of State Regulations
FAA	Federal Aviation Administration
GAC	Granular Activated Carbon
ISO	Insurance Services Office
NFPA	National Fire Protection Association
NIOSH	National Institute of Occupational Safety and Health
NPDES	National Pollutants Discharge Elimination System
NSF	National Sanitation Foundation
NSF	National Science Foundation
OSHA	Occupational Safety and Health Administration
PAC	Powdered Activated Carbon
PDWP	Public Drinking Water Program
PPE	Personal Protective Equipment
PSIG	Pounds per square inch gauge
PVC	polyvinylchloride
RSMo	Revised Statutes of Missouri
USC	United States Code
USDA	United States Department of Agriculture
USGS	United States Geological Survey

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PREAMBLE

What is the Purpose of This Document?

This publication reflects the minimum standards and guidelines of the Missouri Department of Natural Resources in regard to the preparation, submission, review, and approval of engineering reports, plans, and facilities for the construction or modification of community water systems. These standards are necessary for facilities to comply with the Missouri safe drinking water statutes and regulations.

These standards, consisting of proven technology, engineering principles, and sound water works practices, are intended to accomplish the following objectives: to serve as a guide for professional engineers in the design and preparation of engineering reports, plans, and specifications for community public water systems; to suggest limiting values for items upon which evaluation of such engineering reports, plans, and specifications are evaluated by the department; and to ensure that a new or modified community public water system facility will be capable of supplying adequate water in compliance with applicable regulations.

These standards draw heavily on the Recommended Standards for Water Works, commonly known as the “Ten State Standards.” The Great Lakes-Upper Mississippi Board of Public Health and Environmental Managers created a Water Supply Committee in 1950 consisting of one associate from each state represented on the Board (Illinois, Indiana, Iowa, Michigan, Minnesota, Missouri, New York, Ohio, Pennsylvania, and Wisconsin). In 1978, a representative of the Canadian province of Ontario was added. This committee was assigned the responsibility for reviewing existing water works practices, policies, and procedures, and reporting its findings to the Board. The report of the Water Supply Committee was first published in 1953, and has been updated and revised several times since then. The “Ten State Standards” are widely accepted throughout the water works industry as minimum standards for construction of safe water supplies.

To Whom Do These Standards Apply?

These standards apply to new community water systems. These standards also apply to modifications made at existing community water systems. Only the portion of the existing community water system begin modified is subject to these standards. These standards are not an inspection tool for assessing deficiencies in facilities constructed under approvals issued under previous Design Guides. However, where water quality performance is an issue, appropriate portions of these minimum standards may be applied (for example, in Comprehensive Performance Evaluations).

What Does This Document Require?

Where the terms “shall” and “must” are used, mandatory requirements are indicated. These terms are used where practice is sufficiently standardized to permit specific delineation of requirements or where safeguarding public health justifies such definition action. Other terms, such as “should,” “recommended,” and “preferred,” indicate desirable procedures or methods, and deviations are subject to individual consideration, but these terms in no way indicate a requirement.

Deviation from the mandatory "shall" or "must" requirements will be considered by the department on a case-by-case basis, based on the primary purpose of the proposed water works, the local conditions governing their functions, and operation.

In many instances in this document, choices and alternatives are provided for meeting a requirement. For example, the engineering report shall include information on usage rates, water loss rates, unusual conditions, and population per service connection. That is the requirement. However, this information can be based on any one of four alternatives: (1) historical data from the water system if available; OR (2) data from a comparable system; OR (3) calculations of usage criteria using data specified in the document; OR (4) some other usage criteria if adequate justification is provided.

This approach provides flexibility in meeting basic requirements that ensure the proposed new or modified water system provides safe quality and adequate quantities of drinking water. This flexibility is provided where appropriate throughout the document.

Approval of the use of "other criteria," where that option is offered, must, of necessity, be somewhat subjective and situation-specific. However, the department feels it is important to allow this extra degree of flexibility to the water system and its engineers.

What Process Will the Department Use to Evaluate and Accept Alternative Designs?

It is not possible to cover recently developed processes and equipment in a publication of this type. However, it is the policy of the department to encourage rather than obstruct the development of new processes and equipment. Recent developments may be acceptable if they meet at least one of the following conditions:

1. They have been thoroughly tested in full scale comparable installations under competent supervision;
2. They have been thoroughly tested as a pilot plant operated for a sufficient time to indicate satisfactory performance; or
3. A performance bond or other acceptable arrangements have been made so the owners or official custodians are adequately protected financially or in case of failure of the process or equipment.

More specific information and requirements are provided in section 1.1.7.

Regardless of the alternative data presented, the basic criteria for evaluating its merit remains the same: does the alternative criteria offer a comparable level, quantity, and quality of information as the other options offered in the document (usually historical or comparable data or specific calculations), and does the data demonstrate that the alternative design provides equivalent or superior performance under the anticipated extreme operating conditions?

What Process is Available for Appealing the Department's Decision to Reject an Alternative Design?

While the review of most project and construction documents proceeds in a relatively innocuous manner, culminating in an approval being issued, there are times when the PDWP staff engineer and the water system or its consultant may be unable to reconcile a difference. The water system owner/operator may pursue a formal appeal of the department's decision to the Safe Drinking Water Commission, through the authority provided affected parties in section 640.010.1, RSMo; however, the PDWP recommends that the following dispute resolution process be followed prior to resorting to formal procedures:

1. If the PDWP staff engineer determines that the proposed design does not meet regulatory criteria or acceptable engineering practices as established in this document, the PDWP engineer will explain, in writing, the basis for the decision.
2. If the system or its design engineer or consulting engineer disagrees with the PDWP staff engineer's written conclusion, the design or project engineer must submit the basis of their disagreement, in writing, to the PDWP staff engineer.
3. The PDWP staff engineer will share the information submitted by the design or project engineer with management and other professional engineers in the PDWP and solicit their opinions regarding the design or project engineer's response.
4. The PDWP's position on the specific issue will be established by the program director. The PDWP program director's response will be provided to the water system and its engineer(s) within 30 calendar days of the receipt of the system's response identified in item 2, above.

If the water system's owner/operator or consulting engineer remains in disagreement with the department's position, a formal appeal process could be initiated, as applicable, under the authority provided in section 640.010.1, RSMo.

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Chapter 1 -- Submission of Plans

1.0 General

A minimum of two copies of all engineering reports, final plans, and specifications should be submitted at least 30 working days prior to the date on which action by the department is desired. A completed and signed "Application for a Construction Permit" shall be submitted with all detailed plans and specifications. This form can be obtained from the department. Other federal, state, or local agencies may require permits for construction, waste discharges, stream crossings, etc. Preliminary plans and the engineer's report should be submitted for review prior to the preparation of final plans. No approval for construction shall be issued until final, complete, detailed plans and specifications have been submitted to the department and found to be satisfactory. Documents submitted for formal approval shall include but may not be limited to:

a. Applications for a construction permit;
b. A summary of the basis of design, including hydraulic calculations sufficient to demonstrate the system will operate satisfactorily;
c. General layout;
d. Detailed plans;
e. Specifications; and
f. Readily available cost estimates.

1.1 Engineering Report

An engineering report is required for the development of a new water supply system, new water sources, and expansions or modifications to existing water systems that will result in changes to the treatment process and/or overall production capacity. The engineering report shall, where pertinent, present the information listed in this chapter.

1.1.1. General information

General information, including:

a. The name and mailing address of the water system's continuing operating authority as defined in 10 CSR 60-3.020;
b. A description of the existing and proposed water system(s);
c. A description of the existing and proposed sewerage system and sewage treatment works as it affects the existing or proposed water system;
d. An identification of the municipality(-ies) or area served; and
e. An imprint of professional engineer's seal or conformance with State of Missouri's engineering registration requirements.

1.1.2. Extent of the water system(s)

Extent of the water system(s), including the information in items a. through g. below.

a. A description of the nature and extent of the area to be served, including layout maps or drawings showing the legal boundaries of the water system(s).
b. Provisions for extending the water system to include additional areas.
c. Appraisal of the future requirements for service, including existing and potential residential, industrial, commercial, institutional, and other water supply needs.
d. Usage rates, water loss rates, unusual conditions, and population per service connection. This information shall be based on one or more of the alternatives listed in items 1. through 4.
    1. Historical data from the public water system, if available. This data shall be representative of climatic conditions that affect demand and source.
    2. If such historical data from the public water system are not available, data from a comparable water system may be used.
    3. If neither historical nor comparable water system data are available, the following information shall, as a minimum, be used for design purposes:
       i. Population per service connection for permanent residential dwelling units including houses, mobile homes, condominiums, apartments, and multiplexes shall be approximately three (3.0) persons/dwelling unit; and
       ii. Domestic water usage for residential dwelling units excluding lawn/garden irrigation usage shall be an average of 80 gallons per person per calendar day, except that for rural water districts this may be an average of 60 gallons per person per day.
    4. Other usage criteria may be used in lieu of the criteria listed in the preceding item (1.1.2.d.3.) if the engineer provides adequate justification.
e. For lawn watering, the following estimates may be used:

Housing Type	Sprinkler Type	Flow per House
Moderate/Middle Class	End of Hose	1.25 gpm
Estate	Automatic	2 gpm

f. Peak flow (instantaneous, one hour, two hour, three hour, or four hour) shall be based on--
    1. Historical data on the public water system, if available from the water system. These data shall be representative of climatic conditions that affect demand and source. If historical data is used, the entire distribution system hydraulics shall be calculated;
    2. If such historical data from the public water system are not available, data from a comparable water system may be used; or
    3. If neither historical nor comparable water system data are available, the following information shall be used for design purposes:

       Instantaneous Peak Flow = Domestic Peak Flow* + Lawn/Garden Irrigation Peak Flow + Commercial, Larger Users, Confined Feeding Operations

       *Domestic peak flow should be calculated as the greater of:
       1. One gallon per minute per connection, or
       2. Peak = 12(number of connections)$^{0.515}$.

    4. Other peak flow criteria may be used in lieu of the criteria listed in the

preceding item (1.1.2.f.3.) if the engineer provides adequate justification; for example, rural water districts may calculate domestic peak flow as the greater of 0.75 gallons per minute per connection or

$Peak = 9(\text{number of connections})^{0.515}$.

g. Maximum day flow shall be based on:
   1. Historical data if these data are available from the public water system. This data shall be representative of climatic conditions that affect demand and source);
   2. If historical data are not available, data from a comparable system may be used; or
   3. If neither historical or comparable data are available, the following data may be used for design purposes:

      Maximum Day Flow = 150% of Average Day Flow.

   4. Other maximum day flow criteria may be used in lieu of this criteria in 1.1.2.g.3. if the engineer gives adequate justification.

1.1.3. Alternate plans

Where two or more solutions exist for providing public water supply facilities, each of which is feasible and practicable, discuss the alternate plans. Give reasons for selecting the solution recommended, including financial considerations, and a comparison of the certification level of water system operator required.

1.1.4. Soil, ground water conditions, and foundation problems

The engineering report shall specifically address whether the native soils are suitable for main bedding and backfill and note the extent that crushed stone, gravel or other purchased bedding/backfill will be needed, along with estimated costs. The report shall also address the potential for rock excavation in the various soils encountered, along with estimated costs.

1.1.5. Flow requirements

Flow requirements, including:

a. Hydraulic analyses based on flow demands and pressure requirements (see Chapter 8 of this document); and
b. Fire flows, when fire protection is provided, design shall be based on the Insurance Services Office (ISO) Fire Flow Criteria.

1.1.6. Sources of water supply

Describe the proposed source or sources of water supply to be developed, the reasons for their selection, and provide information as follows:

1.1.6.1. Surface water sources

Including where pertinent:

Schedule JAM-4

a. Hydrological data, stream flow, and weather records;
b. Safe yield design as described in section 3.1. of this document;
c. The maximum flood flow and the safety features of the spillway and dam, shall be based on the design criteria of the Missouri Dam and Reservoir Safety Council, regardless of the height of the dam;
d. A description of the watershed, noting any existing or potential sources of contamination (such as highways, railroads, chemical facilities, farming operations, etc.) which may affect water quality, a discussion of land use practices, and provisions for erosion and siltation control structures;
e. Summarized quality of the raw water, with special reference to fluctuations in quality, changing meteorological conditions, etc.; and
f. Source water protection issues or measures that need to be considered or implemented.

1.1.6.2. Ground water sources

a. Consolidated formation groundwater is generally available in very large quantities in southern and central Missouri and withdrawal is not regulated. However, large withdrawals may reduce the volume available in localized areas. The purpose of the hydrogeologic report is to provide information to the public water supply so that rational decisions can be made on location of wells, the possible civil liability of de-watering neighbors, and the practicality of expanding groundwater withdrawal from an ever widening circle versus switching to surface or alluvial sources;
b. The department shall be consulted prior to design and construction regarding a proposed well location as it relates to required separation between existing and potential sources of contamination and groundwater development. The engineering report shall include-
    1. A legal description of sites under consideration;
    2. Advantages of the selected site;
    3. Elevations with respect to surroundings;
    4. Probable character of formations through which the source is to be developed**;**
    5. Geologic conditions affecting the site; for example, any existing sinkholes, caves, test holes, abandoned wells, or anticipated interference between proposed and existing wells. This information can be obtained from the department's Geological Survey and Resource Assessment Division. Water supplies which withdraw or propose to withdraw 2,000,000 gallons per day (2 MGD) or more from wells in consolidated formations and public water supplies that are contiguous with other public supplies which together withdraw or propose to withdraw 2,000,000 gallons per day (2 MGD) or more from wells in consolidated formation, should submit a hydrogeologic report bearing the seal of a geologist registered in Missouri for each consolidated formation well project;

6. A summary of source exploration, test well depth, and method of construction, placement of liners or screen, test pumping rates and their duration, location, sieve analysis**,** water levels and specific yield, and water quality;
7. Existing wells within 1,000 feet radius of the proposed well site, giving their depths, protective casing depths, capacities, and location;
8. Sources of possible contamination within 1,000 feet; such as sewers and sewerage facilities, highways, railroads, landfills, outcroppings of consolidated water-bearing formations, chemical facilities, waste disposal wells, etc;
9. Depths of any known aquifers that will reduce well yield if penetrated;
10. Total depth of all known water bearing aquifers; and
11. Wellhead protection measures being considered.

1.1.7. New Technology

The technologies provided in these design standards are generally based on standards of the American Water Works Association, Recommended Standards for Water Works (commonly called "Ten States Standards"), and other nationally recognized standards. These technologies have a long history of use and can be reasonably expected to perform satisfactorily. However, it is the policy of the department to encourage new technologies for the production, treatment, and distribution of drinking water while continuing to protect the public health.

Any public water system proposing a new technology not addressed in these design standards shall provide and meet the following additional requirements in this subsection.

1.1.7.1. Engineering Report--Additional Requirements for New Technology

a. Complete description of the new technology including the scientific principles upon which the technology is based.
b. A statement indicating if the technology is currently protected by U.S. patents or is otherwise proprietary.
c. Results of full scale operations at other public water systems, with water similar to that of the public water system proposing the installation. These pilot studies shall:
    1. Have protocols including proposed testing parameters approved by the department prior to initiating the pilot study;
    2. Be done in a manner that will assure an acceptable quality of finished water will be produced through all seasonal water quality variations of the source water;
    3. Include a research of historic data to determine the extremes of water quality that may be encountered and the research results submitted in the results of the pilot study submitted with the engineering report;

4. Be conducted under the same operating parameters as the proposed full scale system;
5. Include an assessment of the costs of operation, replacement, and maintenance to be included in the results of the pilot study submitted with the engineering report; and
6. Be done in a manner to show repeatability of performance under the same operating conditions and the effects of long term operation.

d. The expected design life of each equipment component used in the new technology and the present day replacement cost of each component including both material cost and labor cost.

e. A complete description of the training needed for public water system personnel to operate and maintain the new technology including the number of days of training and the cost of training. If initial training is provided with the purchase price, the cost of training additional operators or maintenance personnel must be identified to cover personnel turnover.

f. The estimated number of minutes or hours needed per day, week, month, quarter, or year (as appropriate) including any down time expected to operate and maintain the components of the new technology. Any expected maintenance or repairs that must be done by vendor or factory personnel must also be identified along with costs, frequency, and down-time.

g. The estimated costs of operating and maintaining the new technology.

h. A complete description of standard technology including detailed cost estimates of material, labor, engineering, and contingency that would be needed to replace the new technology in the event the new technology is found to be ineffective.

i. A complete list of operating records, maintenance records, cost records, and testing protocol needed to evaluate the performance of the new technology.

1.1.7.2. Financial Certification.

The public water system's chief financial officer (or equivalent official if appropriate) shall provide written certification to the department that the system has financial resources that are adequate to operate and maintain the new technology and to replace the new technology with standard technology should the new technology be found to be ineffective. This certification shall include the nature of the financial resources, which may include but is not limited to: cash reserves in bank accounts or U.S. Government securities, other investments (stocks, bonds, mutual funds, precious metals, etc.), local bonds passed for this project but left in reserve to cover this contingency, binding agreement with a government funding agency to provide the funding needed to replace the new technology if it proves ineffective, a performance bond meeting the conditions noted in the Performance Contract, or projected annual operating fund surpluses.

1.1.7.3. Performance Contract.

The public water system shall enter into a contract with the department that includes the following elements (A less stringent method would be a written certification instead of a contract):

a. The new technology shall be deemed ineffective if use of the technology results in a maximum contaminant level violation, action level violation, or treatment technique violation listed in 10 CSR 60 during any three months during a running 12-month period over the life of the performance period;

b. The new technology shall be deemed ineffective if use of the technology results in water outages or pressure reduction below 20 pounds per square inch gage (20 psig) during any three months during a running 12-month period over the life of the performance period;

c. The public water system shall maintain financial resources to replace the new technology with standard technology during the life of the contract. The reserve funds needed shall be initially based on the standard technology cost estimate from the engineering report and shall be increased annually for inflation using the federal consumer price index (or other suitable index);

d. The public water system will provide the operation and maintenance, including operator and maintenance personnel training, as outlined in the engineering report;

e. The public water system will collect and record all operation, maintenance, and cost records and perform all analysis outlined in the engineering report;

f. The public water system shall obtain the services of a professional engineer registered in Missouri to oversee data collection, record keeping, and provide a complete engineering analysis of the new technology after one year of operation, after the performance period is completed, and (if needed) following the department issuing a preliminary intent to declare the technology ineffective for this public water system. The professional engineer shall submit two copies of the engineering analysis to the department within six months of the end of the first year, within six months of the end of the performance period, and within six months of the department issuing a preliminary intent to declare the technology ineffective for this public water system. This engineering analysis shall evaluate the effectiveness of the new technology for its intended purpose and list all data and calculations supporting this evaluation, note any problems with operation or maintenance and including how, when, or if these problems were solved, note actual times spent operating and maintaining the new technology and compare these with those estimated in the engineering report, calculate costs of operating and maintaining the new technology and compare these with those estimated in the engineering report, complete a reassessment of the expected life of major components of the new technology, include the engineer's conclusion as to whether or not this technology was effective for this public water system and include the engineer's recommendation (with any reservations) as to whether or not this technology should be widely approved for similar application;

g. If the public water system has maximum contaminant level violations, action level violations, treatment technique violations, or low pressure violations at the frequency noted above in items a. and b., that, in the department's opinion, could be the result of use of the new technology, the department shall issue a preliminary intent to declare the new technology ineffective for this public water system. The public water system shall then submit the engineering evaluation within the time frame noted above in item f.;

h. The department shall review the engineering evaluation and conduct other investigations as it deems necessary including, but not limited to, investigations by department employees or contractors, invitations to submit analysis from the vendor, manufacturer, and original project engineer (if different from the evaluation engineer). Within six months of submittal of the engineering evaluation by the public water system, the department shall make a formal determination of whether or not the new technology is ineffective for this public water system; and

i. If the department formally determines the new technology is ineffective for this public water system, the public water system shall:
    1. Within 180 calendar days, submit engineering plans and specifications prepared by a professional engineer registered in Missouri and a completed construction permit application to the department for replacing the new technology with the standard technology identified in the original engineering report;
    2. Within 30 calendar days of receipt of any request from the department for additional information or changes in the engineering plans and specifications, the public water system shall submit these modifications to the department;
    3. Within 180 calendar days of the department's approval to construct, the public water system shall construct the new facilities; and
    4. Within 21 calendar days of completion of construction, the public water system shall submit to the department certification by the professional engineer stating that the project has been substantially completed in accordance with the approved plans and specifications.

1.1.7.4. Performance Period.

The length of the performance period shall be the lesser of 60 months or the expected life of the major components of the new technology. The life of the contract shall be the performance period plus 12 months, which includes six months for the engineering analysis and six months for the department's final determination of effectiveness.

1.1.7.5. (no title)

Initially, the department will approve only one project for a particular new technology statewide. After the department completes review of the one year engineering evaluation of this first project, the department may approve an additional nine projects for a particular new technology statewide. If any project is formally declared to be ineffective, all approvals shall cease until the department reassesses the new technology and determines if the failure was site specific or more general.

1.1.7.6. (no title)

After the completion of ten successful projects for a particular new technology and department review of all engineering evaluations, the department may promulgate design regulations allowing the new technology to become standard technology or may allow additional projects to gather more information if needed. Ultimately, the department will either promulgate regulations making the new technology standard technology or will declare the new technology inappropriate for use in Missouri.

1.1.8. Project Sites.

The area and approximate geometry of the proposed site shall be identified and the adequacy for adding additional facilities on the site, and for providing adequate security. To the extent practical, all new or expanded water systems shall not be located on sites:

a. That are subject to a significant risk from earthquakes, floods, fires, pollution or other disasters which could cause a breakdown of the public water system or a portion of the system, and, except for intake structures, are within the floodplain of a 100-year flood where appropriate records exist;

b. That are in the proximity of residences, industries, and other establishments; and

c. With any potential sources of pollution or other factors that may influence the quality of the supply or interfere with effective operation of the water works system, such as sewage absorption systems, septic tanks, privies, cesspools, sinkholes, sanitary landfills, refuse and garbage dumps.

1.2. Plans.

Plans for water systems shall be no larger than standard size 24 inches by 36 inches.

1.2.1. Plans shall include:

a. Suitable title and index;
b. The name of the municipality, or other entity or person responsible for the water supply;
c. Scale, in feet;
d. North point;
e. U.S.G.S. datum used, critical mean sea level (msl) elevations for new and existing tanks determined from surveys beginning at USGS or department elevation monuments and copies of the survey;
f. Legible prints suitable for reproduction;
g. Date, name, and address of the designing engineer;
h. Imprint of professional engineer's seal in conformance with State of Missouri's engineering registration requirements;
i. Boundaries of municipality, water district, or area to be served;
j. Location and size of existing water mains;
k. Location and nature of existing water system structures and appurtenances affecting the proposed improvements, noted on one sheet;
l. Location and description of existing and/or proposed sewerage system;
m. Location of proposed water mains and water system structures, with size, length and identity;
n. Contour lines at suitable intervals; and
o. Names of streets and roads.

1.2.2. Detailed plans, **including:**

a. Stream crossings, providing profiles with elevations of the streambed, and the normal and extreme high and low water levels;
b. Profiles, where necessary, having a horizontal scale of not more than 100 feet to the inch and a vertical scale of not more than ten feet to the inch, with both scales clearly indicated. (Note: This does not apply to entire distribution systems.);
c. Location and size of the property to be used for the water works development with respect to known references such as roads, streams, section lines, or streets;
d. Topography and arrangement of present or planned wells or structures, with contour intervals not greater than two feet;
e. One hundred-year flood plain or elevations of the highest known flood level, floor of the structure, upper terminal of protective casings and outside surrounding grade, using United States Coast and Geodetic Survey, United States Geological Survey or equivalent elevations where applicable as reference;
f. Plat and profile drawings of well construction, showing the diameter and depth of drill holes and casing**s**; liner diameters; grouting depths; elevations and designation of geological formations; water levels and other details to describe the proposed well completely;

g. Location of all existing and potential sources of pollution within 1,000 feet of the source, and within 300 feet of underground treated water storage facilities;
h. Size, length, and identity of sewers, drains, and water mains, and their locations relative to plant structures;
i. Schematic flow diagrams and hydraulic profiles showing the flow through various plant units;
j. Piping in sufficient detail to show flow through the plant, including waste lines;
k. Locations of all chemical storage areas, feeding equipment, and points of chemical application;
l. All appurtenances, specific structures, equipment, water treatment plant waste disposal units, and points of discharge having any relationship to the plans for water mains and/or water system structures;
m. Locations of sanitary or other facilities, such as lavatories, showers, toilets, floor drains, etc.;
n. Locations, dimensions, and elevations of all proposed plant facilities;
o. Locations of all sampling taps; and
p. Adequate description of any features not otherwise covered by the specifications.

1.3. Specifications.

Complete, detailed technical specifications shall be supplied for the proposed project, including:

a. A description of how existing water system facilities will continue in operation during renovation or construction of additional facilities to minimize interruption of service;
b. The specification of laboratory facilities and equipment;
c. The number and design of chemical feeding equipment;
d. A description of materials or proprietary equipment for sanitary or other facilities including necessary cross-connection protection;
e. The specification of manufactured products such as pipe, valves, fittings, hydrants, steel, Portland cement, etc. by the appropriate national standard, sufficient to differentiate the exact product. Any stamp or marking required to identify the product as meeting the national standard and an affidavit from the manufacturer stating that the product meets the national standard. The standard names, number, effective date, publication date, name and address of the organization issuing the standard shall identify the national standard. Specifications for manufactured products may also include the complete detailed national standard at the discretion of the engineer;
f. All procedures, methods, testing requirements, and products except manufactured products noted in paragraph 1.3.e. above, specified by the appropriate national standard and all details of the national standard needed to properly construct the water system component shall be included in the specifications. The standard

name, number, effective date, publication, name and address of the organization issuing the standard shall identify the national standard; and

g. Where performance specifications are used, shop drawings must be provided.

1.4. Summary of Design Criteria.

A summary of complete design criteria shall be submitted for the proposed project, including but not limited to the following:

a. Long-term dependable yield of the source of supply;
b. Reservoir surface area, volume, and a volume-versus-depth curve;
c. Area of watershed;
d. Estimated average and maximum day water demands for the design period;
e. Number of proposed services;
f. Fire fighting requirements;
g. Flash mix, flocculation and settling basin capacities;
h. Retention times;
i. Unit loadings;
j. Filter area and the proposed filtration rate;
k. Backwash rate; and
l. Chemical feeder capacities and ranges.

1.5. Additional Information.

The department may require additional information, which is not part of the construction drawings, such as head loss calculations, proprietary technical data, copies of deeds, copies of contracts, shop drawings, etc.

1.6. Revisions to Approved Plans.

a. Any deviation from approved plans or specifications affecting capacity, hydraulic conditions, operating units, the functioning of water treatment processes, or the quality of water to be delivered must be approved in writing before such changes are made.
b. Revised plans or specifications shall be submitted to the department for review and approval before any construction work affected by such changes is started.

1.7. Final Approval of Construction.

a. Final construction approval must be obtained from the department for all projects for which approval is required before that project is placed into service.
b. Upon completion of the construction, the engineer must:
    1. Notify the department and establish a mutually satisfactory time for making a final inspection, certify in writing that the construction is substantially completed in accordance with approved plans and specifications and change orders**;**
    2. Submit two copies of as-built plans to the department;
    3. Show that water quality is acceptable to the department; and

4. Submit the final cost of the project with all components of cost identified.

c. In larger projects, an interim (partial) approval may be secured for the completed parts of the water system before they are placed in service.

1.8. Supervised Program.

a. A supplier of water may apply for an owner-supervised program in lieu of submitting plans and specifications for expansion or modification of an existing water distribution system.

b. A written request to the Department of Natural Resources for approval of a supervised program shall include the following information:

1. An engineer-prepared report or a master plan showing the proposed waterlines over at least the next five years, along with engineering rationale, including hydraulic analyses, for sizing and locating the lines. The engineering report shall discuss adequacy of present water system with regard to the source, storage and existing distribution piping, problems that need to be resolved (leaks, low pressures, etc.), and fire protection needs (if applicable). A priority listing of proposed improvements along with cost estimates should also be included in the engineering report;
2. A current layout map, or maps, of the distribution system (standard size 24" x 36"). The map(s) shall show waterline sizes (existing and proposed), location of valves, fire hydrants and flushing devices, along with street names;
3. Adoption of a minimum pipe size for waterline replacements not otherwise shown on the master plan which shall maintain a minimum pressure in accordance with Chapter 8 of this document;
4. Examples of permanent records and drawings of the distribution system including lines, valves, hydrants and cleanouts;
5. Technical specifications prepared by an engineer covering construction materials, installation, and disinfection procedures in accordance with American Water Works Association standards;
6. Typical detail drawings by an engineer of special crossings, meter settings, valve settings, hydrant settings, cleanouts, thrust blockings, etc.;
7. A brief statement about qualifications of the person responsible for construction inspection;
8. A description of how permanent records and drawings will be provided. If permanent records and drawings are to be prepared by a consulting engineer, a copy of the agreement with the firm shall be provided; and
9. Examples of inspection forms to be used to inspect water mains and appurtances.

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Chapter 2 - General Design Considerations

2.0. General.

The design of a water supply system or treatment process encompasses a broad area. Application of this chapter depends on the type of system or process involved.

2.1. Design Basis.

The system shall be designed for maximum day demand at the design year.

2.2. Plant Layout.

Design shall consider:

a. Functional aspects of the plant layout;
b. Provisions for future plant expansion;
c. Provisions for expansion of the plant waste treatment and disposal facilities;
d. Access roads, driveways, walks, and fencing;
e. Site grading and drainage;
f. Chemical delivery; and
g. Security of facilities.

2.3. Building Layout.

Design shall provide for:

a. Adequate ventilation, lighting, emergency lighting, heating, and floor drainage;
b. Dehumidification equipment, if necessary;
c. Accessibility of equipment for operation, servicing, and removal;
d. Flexibility of operation, convenience of operation, and operator safety;
e. Chemical storage and feed equipment in ~~a~~ separate rooms to reduce hazards and dust problems; and
f. Adequate facilities should be included for shop space and storage, consistent with the designed facilities.

2.4. Siting Requirements.

a. Site shall not be subject to a significant risk from floods, fires, pollution, or other disasters, which could cause a breakdown of the public water supply system or portion thereof.
b. Non-submersible intake pumping equipment and accessories shall be located or protected to at least four feet above the 100-year flood elevation or the highest flood elevation on record.
c. The department shall be consulted regarding any structure that may impede normal or flood stream flows.
d. In earthquake prone areas, structures should be designed to withstand earthquake effects.

e. The site will provide all-weather access road to all significant facilities.

2.5 Security Measures

a. All water system facilities shall be designed to include measures to provide protection against vandalism, sabotage, terrorist acts, or access by unauthorized personnel. These protection measures shall include:
    1. Locked security doors;
    2. Windows sized or barred to prevent human entrance; and
    3. Security fencing around vulnerable areas of drinking water facilities (for example, wellheads, manholes, pumphouse, treatment buildings and storage tanks).

b. Other items from the following list should be included as needed to provide security commensurable with the importance of the facility to the overall water supply and the probability of the security breach.
    1. Perform a vulnerability assessment to effectively uncover your system's vulnerable points in order to successfully secure your facility.
    2. Prepare (or update) an Emergency Response Plan. Plans should be reviewed annually and all employees must receive adequate training to effectively carry out the emergency plan, thereby becoming familiar and confident with their roles in an emergency situation.
    3. Post emergency contact numbers at your facilities, in your consumer confidence reports, customer bills, web pages and any other highly visible area such as the office, pump-house, and on your vehicles. All personnel should have updated emergency contact numbers, which should be shared with your local law enforcement and response officials.
    4. Get to know your local law enforcement and ask them to add your facilities to their routine rounds. Practice emergency response procedures with local law enforcement, emergency responders and public health officials.
    5. Lock all access points to your facility (for example, access gates, doors, windows, hatches, finished water). Also, lock monitoring wells to prevent vandals or terrorists from pouring contaminants directly into ground water near your source. Set alarms to indicate illegal entry.
    6. Install motion activated lights around the perimeter of the pump-house, treatment facility and parking lot.
    7. Limit access to your water system. Do not allow anyone unassociated with your system to enter or wander around your facility. Verify the identity of delivery people. Request strangers to leave, or call local law enforcement if you have trespassers.
    8. Monitor water quality aggressively and be observant for unusual conditions including signs of intrusion and/or contamination (unusual water color, odors, sheens, fish kills and sudden increased chlorine demand).
    9. In the event of an emergency, follow your emergency response plan and contact the Public Drinking Water Program.

2.6. Electrical Controls.

Main switch gear electrical controls shall be located above grade, and in areas not subject to flooding.

2.7. Standby Power.

For the system's own protection, standby power or an alternate power source should be provided so that water may be treated and/or pumped to the distribution system during power outages to meet average day demand. Systems serving a population of 3,300 or greater shall have arrangements in place for standby or backup power and shall include these arrangements in their emergency operating plan.

2.8. Laboratory Equipment.

Each public water supply shall have its own equipment and facilities for routine laboratory testing necessary to ensure proper operation. Laboratory equipment selection shall be based on the characteristics of the raw water source and the complexity of the treatment process involved. Laboratory test kits that simplify procedures for making one or more tests may be acceptable. Analyses conducted to determine compliance with drinking water regulations must be performed in an appropriately certified laboratory in accordance with methods approved by the department. Persons designing and equipping facilities for which laboratory certification by the department is desired shall confer with the department before beginning the preparation of plans or the purchase of equipment. Methods for verifying adequate quality assurance and for routine calibration of equipment shall be provided.

2.8.1. Testing equipment.

a. Surface water supplies:
   1. Shall have a bench model Nephelometric turbidimeter to monitor entry point to the distribution system;
   2. Shall have continuous Nephelometric turbidity monitoring and recording equipment on each filter located to monitor effluent and filter to waste;
   2. Shall have electrode pH meter;
   3. Shall have equipment necessary to perform jar test;
   4. Shall have titration equipment for both hardness and alkalinity; and
   5. Should provide the necessary facilities for microbiological testing of water from both the treatment plant and the distribution system.

b. Groundwater supplies, where pertinent:
   1. Shall have test equipment capable of accurately measuring iron and manganese to a minimum of 0.05 milligram per liter;
   2. Shall have electrode pH meter;
   3. Shall have titration equipment for both hardness and alkalinity; and
   4. With lime softening facilities, should have a Nephelometric turbidimeter.

c. Public water supplies that**:**
   1. Chlorinate shall have test equipment for determining both free and total

chlorine residual by methods in "Standard Methods for the Examination of Water and Wastewater";

2. Fluoridate shall have test equipment for determining fluoride by methods in "Standard Methods for the Examination of Water and Wastewater"; and
3. Feed polyphosphates and/or orthophosphates shall have test equipment capable of accurately measuring phosphates from 0.1 to 20 milligrams per liter.

2.8.2. **Physical facilities**.

Sufficient bench space, adequate ventilation, adequate lighting, electrical receptacles, storage room, laboratory sink, and auxiliary facilities shall be provided. Air conditioning may be necessary.

2.9. Monitoring and Recording Equipment.

Water treatment plants with a capacity of 0.5 mgd or more should be provided with continuous monitoring and recording equipment to monitor water being discharged to the distribution system as follows:

a. Plants treating surface water and plants using lime for softening should have the capability to monitor and record free chlorine residual and pH. In addition, continuous monitoring of entry point disinfection residuals shall be provided for systems with a service population greater than 3,300 people. Monitoring of the parameters to evaluate adequate CT disinfection, such as residuals, pH and water temperature, should be provided; and
b. Plants treating ground water using iron removal and/or ion exchange softening should have the capability to monitor and record free chlorine residual.

2.10. Plant Sample Taps.

a. Sample taps shall be provided so that water samples can be obtained from each water source and from appropriate locations in each unit operation of treatment.
b. Taps shall be consistent with sampling needs and shall not be of the petcock type.
c. Taps used for obtaining samples for bacteriological analysis shall be of material that resist flaming, smooth-nosed type without interior or exterior threads, shall not be of the mixing type, and shall not have a screen, aerator, or other such appurtenances.

2.11. Facility Water Supply.

a. The facility water supply service line and the plant finished water sample tap shall be supplied from a source of finished water at a point where all chemicals have been thoroughly mixed, and the required disinfectant contact time has been achieved.
b. There shall be no cross-connections between the facility water supply service line and any piping, troughs, tanks, or other treatment units containing wastewater, treatment chemicals, raw or partially treated water.

2.12. Wall Castings.

Consideration shall be given to providing extra wall castings built into the structure to facilitate future uses whenever pipes pass through walls of concrete structures.

2.13. Meters.

All water supplies shall have an acceptable means of metering the raw water flow, finished water flow, flow through the treatment plant, and treatment plant service flow.

2.14. Piping Color Code.

a. To facilitate identification of piping in plants and pumping stations the color scheme in Table 1 is recommended.

Figure 1 - Piping Color Code

TYPE OF PIPE	PIPE COLOR
WATER LINES	
Raw	Olive
Settled or Clarified	Aqua
Finished or Potable	Dark Blue
CHEMICAL LINES	
Alum or Primary Coagulant	Orange
Ammonia	White
Carbon Slurry	Black
Caustic	Yellow with Green Band
Chlorine (Gas and Solution)	Yellow
Fluoride	Light Blue with Red Band
Lime Slurry	Light Green
Ozone	Yellow with Orange Band
Phosphate Compounds	Light Green with Red Band
Polymers or Coagulant Aids	Orange with Green Band
Potassium Permanganate	Violet
Soda Ash	Light Green with Orange Band
Sulfuric Acid	Yellow with Red Band
Sulfur Dioxide	Light Green with Yellow Band
WASTE LINES	
Backwash Waste	Light Brown
Sludge	Dark Brown
Sewer (Sanitary or Other)	Dark Gray
OTHER	
Compressed Air	Dark Green
Gas	Red
Other Lines	Light Gray

In situations where two colors do not have sufficient contrast to easily differentiate between them, a six-inch band of contrasting color should be on one of the pipes at approximately 30-inch intervals. The name of the liquid or gas should also be on the pipe. In some cases, it is also advantageous to provide arrows indicating the direction of flow.

2.15. Disinfection.

All wells, pipes, tanks, and equipment which can convey or store potable water shall be disinfected in accordance with the current AWWA procedures. Plans or specifications shall outline the procedure and include the disinfectant dosage, contact time, and method of testing the results of the procedure.

2.16. Manuals and Parts List.

An operation and maintenance manual including a parts list and parts order form shall be supplied to the water system as part of any proprietary unit installed in the facility. Written instruction for the start-up of the plant or pumping station shall be provided to the water system owner.

2.17. Other Considerations.

Consideration must be given to the design requirements of other federal, state, and local regulatory agencies for items such as safety requirements, special designs for the handicapped, plumbing and electrical codes, construction in a flood plain, etc.

2.18. Automation.

The department encourages measures, including automation, which assist operators in improving plant operations and surveillance functions. Automation of surface water treatment facilities to allow unattended operation with off-site control presents a number of management and technological challenges that must be overcome before an approval can be considered. Each facet of the plant facilities and operations must be fully evaluated to determine what on-line monitoring is appropriate, what alarm capabilities must be incorporated into the design and what staffing is necessary. Consideration must be given to the consequences and operational response to treatment challenges, equipment failure and loss of communications or power.

The engineering report to be submitted to the department for review must cover all aspects of the treatment plant and automation system including the following information/criteria:

1. Identification of all critical features in the pumping and treatment facilities that will be electronically monitored, have alarms and can be operated automatically or off-site via the control system. Include a description of automatic plant shutdown controls with alarms and conditions that would trigger shutdowns. Dual or secondary alarms may be necessary for certain critical functions;

2. Provision for automated monitoring of all critical functions with major and minor alarm features. Automated plant shutdown is required on all major alarms. Automated remote startup of the plant is prohibited after shutdown due to a major alarm. The control system must have response and adjustment capability on all minor alarms. Built-in control system challenge test capability must be provided to verify operational status of major and minor alarms;
3. The plant control system that has the capability for manual operation of all treatment plant equipment and process functions;
4. A plant flow diagram that shows the location of all critical features, alarms and automated controls to be provided;
5. Description of off-site control station(s) that allow observation of plant operations, receiving alarms and having the ability to adjust and control operation of equipment and the treatment process;
6. Description of optimal staffing for the plant design, including meeting requirements in 10 CSR 60-14.010 for certified operators; an on-site check at least once per day by a certified operator to verify proper operation and plant security; and sufficient appropriate staffing to carry out daily on-site evaluations, operational functions, and maintenance and calibration of all critical treatment components and monitoring equipment and weekly checks of the communication and control system to ensure reliability of operations. Challenge testing of such equipment should be part of normal maintenance routines;
7. Description of operator training planned or completed in both process control and the automated system;
8. Operations manual, which gives operators step-by-step procedures for understanding and using the automated, control system under all water quality conditions. Emergency operations during power or communications failures or other emergencies must be included;
9. A plan for a 6-month or more demonstration period to prove the reliability of procedures, equipment and surveillance system. A certified operator must be on duty during the demonstration period. The final plan must identify and address any problems and alarms that occurred during the demonstration period. Challenge testing of each critical component of the overall system must be included as part of the demonstration project;
10. A schedule for maintenance of equipment and critical parts replacement;
11. Provision for sufficient finished water storage to meet system demands and CT requirements whenever normal treatment production is interrupted as the result of automation system failure or plant shutdown; and
12. Provision for ensuring security of the treatment facilities at all times. Incorporation of appropriate intrusion alarms must be provided which are effectively communicated to the operator in charge. See section 2.5 Security Measures.

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Chapter 3 - Source Development

3.0. General.

In selecting the source of water to be developed, the design engineer must prove that an adequate quantity of water will be available. The proposed groundwater or surface water supply must be adequate for future water demands during the design period. Water that is to be delivered to the consumers will meet the current requirements of the department with respect to microbiological, physical, chemical and radiological qualities. Each water supply should take its raw water from the highest quality and sustainable source that is economically reasonable and technologically possible.

3.1. Surface Water.

A surface water source includes all tributary streams and drainage basins, natural lakes, and artificial reservoirs above the point of water supply intake.

3.1.1. Quantity.

3.1.1.1. Reservoir Storage Volume.

a. Reservoir storage volume shall provide a reasonable surplus for reserve storage and anticipated growth. A reasonable amount of surplus reserve storage should be considered in order to maintain public confidence in the reliability of supply at predicted depletion levels during a prolonged severe drought. A minimum of 120 days surplus reserve storage should be considered.
b. Reservoir storage volume shall be adequate to compensate for all losses such as silting, evaporation, seepage, and stagnation.

3.1.1.2. Reservoir Capacity.

a. When multiple water sources are provided, the amount of water needed from the proposed reservoir shall be stated and that amount plus water losses due to sediment, evaporation, seepage, and stagnation shall be used to design the reservoir capacity.

b. The capacity of a water supply reservoir shall be determined by using a reservoir operations model such as the USDA Natural Resource Conservation Service's Procedures for Determining Runoff and Reservoir Operation Study. A reservoir study shall be conducted for the drought of record using future design period demand for the water system. The design draft shall include water losses due to sediment, evaporation, seepage, and stagnation as well as the predicted water system demand. Losses due to sediment shall be the accumulated loss predicted at the end of the design period of the reservoir. Climatic data such as precipitation and evaporation used shall be as specific to the proposed reservoir site as is possible. The usable quantity of water in a reservoir shall be sufficient to provide carryover storage at all design future demands and shall include a sufficient reserve to maintain public confidence in the reliability of supply at predicted depletion levels. Water supply availability and storage capacity must meet future water demands of all water users through the multiyear drought of record, presently from 1953 through 1958.

3.1.1.3. River or Stream as the Sole Source of Water.

When a river or stream is to be used as the sole source of water, the flow in the river or stream shall exceed the current registered and future downstream uses, instream flow recommendations, usually the 7 day Q 10 flow rate, and the design year future water system demand. Historical data must be used to determine that stream flows are adequate. Where the nearest gauging station is downstream of the intake site, a drainage area ratio or other approved method to represent the intake location must adjust the flow data. Data from an upstream station may be used. For streams where data does not cover the drought of record, data from similar streams may be used to correlate or predict stream flows, with department approval.

The necessary permits and approvals to install an intake into a stream or river shall be obtained. The conditions on a permit may significantly affect the quantity and rate that may be pumped and the carryover storage required. The usable capacity of the raw water storage reservoirs shall provide carryover storage for the worst case conditions of record. Design demand analysis from the stream or river shall meet all predicted system demands, shall meet permit conditions, shall include the ability to refill the off-stream reservoirs and shall account for evaporation and seepage from all the reservoir storage structures.

3.1.1.4. Supplemental Pumping.

Where pumping is used to supplement runoff to a water supply reservoir, a reservoir operation study shall be developed to determine if stream flows, runoff and carryover storage are adequate. The design demand shall include water losses due to evaporation and seepage, all reservoir design life sediment storage, dead pool, losses and all the predicted water system demand. A written pumping plan shall be provided that includes the minimum lake level that will be allowed before pumping is initiated, and the recommended pumping rates and quantities. The pumping plan must take into account water quality concerns, such as increased settable solids, turbidity, and microbiological and chemical constituents due to storm runoff events, thereby reducing the amount of available pumping.

3.1.2. Quality.

A sanitary survey and study shall be made of the factors, both natural and man-made, which may affect water quality in the water supply lake or reservoir. The design of a water treatment plant must consider the worst condition that may exist during the life of the facility. Such survey and study shall include, but may not be limited to:

a. Determining possible future uses of lakes or reservoirs;
b. Determining the owner's degree of control over the watershed;
c. Assessing the degree of hazard to the supply posed by agricultural, domestic or industrial contaminant sources including municipal and industrial wastewater treatment plants, and animal feeding operation lagoons, recreational and residential activities in the watershed and by the accidental spillage of materials that may be toxic, harmful, or detrimental to treatment processes;
d. Obtaining samples over a sufficient period of time to assess the microbiological, physical, chemical, and radiological characteristics of the water;
e. Assessing the capability of the proposed treatment process to reduce contaminants to applicable standards;
f. Considerations of current, wind and ice conditions,
g. Development, to the extent possible, of a watershed protection plan; and
h. Identification of all possible point and non-point sources of contamination discharges**.**

3.1.3. Structures.

3.1.3.1. Intake structure design.

Design of intake structures shall provide for:

a. Withdrawal of water from more than one level if quality varies with depth;
b. Separate facilities for release of less desirable water held in storage;
c. Limiting the velocity of flow into the intake structure to a minimum, generally not to exceed 0.5 foot per second, where frazil ice may be a problem;
d. Occasional cleaning of the inlet line;
e. Adequate protection against rupture by dragging anchors, ice, etc.;
f. Ports located above the bottom of the stream, lake or reservoir, but at sufficient depth to be kept submerged at low water;
g. A diversion device capable of keeping large quantities of fish or debris

from entering an intake structure, where shore wells are not provided;

h. Where deemed necessary, provisions shall be made in the intake structure to control the influx of zebra mussels or other aquatic nuisances. Specific methods to control zebra mussels shall be approved by the Missouri Department of Natural Resources;
j. When buried surface water collectors are used, sufficient intake opening area must be provided to minimize inlet headloss. An entrance velocity of 0.1 feet per second is recommended. Particular attention should be given to the selection of backfill material in relation to the collector pipe slot size and gradation of the native material over the collector system; and
k. Devices restricting access to intakes.

3.1.3.2. Raw water pumping wells and transmission mains.

Raw water pumping wells and transmission mains shall:

a. Have necessary motors and electrical controls and non-submersible pumps and motors located above grade and protected from flooding as required by the department;
b. Be accessible but have devices restricting access to only authorized personnel;
c. Be designed against flotation;
d. Be equipped with removable or traveling screens before the pump suction well;
e. Provide for introduction of chlorine or other chemicals in the raw water transmission main if necessary for quality control;
f. Have valves and provisions for flushing or cleaning by a mechanical device and testing for leaks;
g. Have provisions for withstanding surges and be protected against damage by floating debris where necessary;
h. Not provide water services on raw water transmission mains to water treatment facilities or provide pressure tanks and additional pumps to adequately supply any services allowed; and
i. Provide meters on any water services on a raw water transmission main.

3.1.3.3. Raw water storage reservoir.

An off-stream raw water storage reservoir is a facility into which water is pumped during periods of good quality and high stream flow for future release to treatment facilities. Raw water storage reservoirs shall be constructed to assure that:

a. Water quality is protected by controlling runoff into the reservoir;
b. Dikes are structurally sound and protected against wave action and erosion;
c. Intake structures and devices meet the requirements of paragraph 3.1.3.1. of this document;

d. Point of influent flow is separated from the point of withdrawal; and
e. Separate pipes are provided for influent to and effluent from the reservoir.

3.1.4. Lakes and reservoirs.

3.1.4.1. Site preparation.

Site preparation shall provide, where applicable:

a. Removal of brush and trees to high water elevation;
b. Protection from floods during construction; and
c. Proper abandonment of all wells that will be inundated, in accordance with subparagraph 3.2.5.15. of this document.

3.1.4.2. Construction.

3.1.4.3.2. Construction shall require:

- a. Silt basins and erosion control structures as a part of the lake design. Instead of providing additional lake volume for silt, silt catch basins should be provided;
- b. Silt basin design that allows them to be drained and silt routinely removed from the basins; and
- c. Sufficient fencing around the lake to prevent access to the lake by livestock.

3.1.4.2.1. Construction may require:

- a. Approval from the appropriate regulatory agencies of the safety features for stability and spillway design;
- b. A permit from an appropriate regulatory agency for controlling stream flow or installing a structure on the bed of a stream or interstate waterway;
- c. A permit from the Department of Natural Resources' Water Pollution Control Program for land disturbance;
- d. Restricted access to the dam; and
- e. A 300-foot green belt around the perimeter of each water supply lake.

3.1.4.3. Water supply dams.

Water supply dams shall be constructed in accordance with the design guidelines of the Missouri Dam and Reservoir Safety Council.

3.1.4.4. Recreational uses of public water supply lakes.

Every supplier of water to a public water system shall secure the approval of the department before permitting the use of public water supply impoundments for recreational usage.

a. Regulated recreational activities are permitted when provisions for such activities are included in the original planning, construction, and approval of the impoundment and water treatment facilities.
b. Recreational activities proposed for existing impoundments will be appraised in the light of the effect on the primary purposes of the impoundment, the capability of the water treatment systems, the physical adaptability of the impoundment to the desired recreational use, and the maintenance of public confidence in the water supply.
c. Provisions shall be made for local enforcement of all rules and ordinances governing recreation. Rules must be posted and maintained in legible condition at conspicuous points in the impoundment area. If rules and ordinances cannot be effectively enforces, recreation shall not be provided.

3.2. Groundwater.

A groundwater source includes all water obtained from drilled wells that is not under the direct influence of surface water.

3.2.1. Quantity.

3.2.1.1. Minimum capacity.

The total developed groundwater source capacity shall equal or exceed the design maximum day demand.

3.2.1.2. Number of sources.

a. Because wells drilled into unconsolidated formations must be routinely removed from service for cleaning and redevelopment, all water systems served by these wells shall have more than one well and shall be capable of meeting maximum day demand with the largest producing well out of service.
b. Public drinking water systems serving 500 or more people shall have more than one well and shall be capable of meeting design maximum day demand with the largest producing well out of service.
c. Public drinking water systems serving less than 500 people should have more than one well and should be capable of meeting design maximum day demand with the largest producing well out of service. In determining the minimum number of wells needed, the supplier of water should consider such factors as the amount of system storage, the critical nature of businesses being served by the water system (for example, hospitals), and the amount of

water needed.

3.2.1.3. Auxiliary power.

a. When power failure would result in cessation of minimum essential service, sufficient power should be provided to meet average day demand through:
    1. Connection to at least two independent public power sources; or
    2. Portable or in-place auxiliary power.
b. When automatic pre-lubrication of pump bearings is necessary, and an auxiliary power supply is provided, the pre-lubrication line shall be provided with a valved by-pass around the automatic control, or the automatic control shall be wired to the emergency power source.

3.2.2. Quality

3.2.2.1. Microbiological quality.

a. Tools, pumps, pipe, gravel pack material, drilling equipment and water used during drilling should be treated with a 200 milligrams per liter chlorine solution. Wells should be tested for any signs of iron or sulfur bacteria contamination after drilling. If possible, the water in the aquifer should be tested before drilling a production well to determine if iron or sulfur reducing bacteria are naturally present.
b. Disinfection of every new, modified or reconditioned groundwater source shall be:
    1. In accordance with the latest AWWA Standard A-100;
    2. Provided after completion of work if a substantial period elapses prior to test pumping or placement of permanent pumping equipment;
    3. Provided after placement of permanent pumping equipment; and
    4. Provided any time the pump or column pipe is removed or replaced.
c. After disinfection, one or more water samples shall be submitted to a laboratory certified by the department for microbiological analysis and the results reported to the department prior to placing the well into service**.** Before placing the well in service, water samples for microbiological analysis shall test absent for coliform bacteria on two consecutive days from wells drilled in consolidated formations. Water from most wells in unconsolidated formations is sent to a water plant for treatment and disinfection. Microbiological analysis of water samples from these wells shall

be done to determine the degree and extent of microbiological contamination present but the presence of coliform bacteria is not grounds for rejection of these wells. However, tests for more than total coliform bacteria should be considered.

3.2.2.2. Physical and chemical quality.

a. Every new, modified, or reconditioned groundwater source shall be examined for applicable physical and chemical characteristics by tests of a representative sample in a laboratory certified by the department.
b. Samples shall be collected at the conclusion of the test pumping procedure and examined as soon as practicable (within the specified holding period).
c. Field determinations of physical and chemical constituents or special sampling procedures may be required by the department.

3.2.2.3. Radiological quality.

Each new or modified groundwater source shall be examined for radiological activity as required by the department.

3.2.3. Location.

3.2.3.1. Well location.

a**.** Prior to design and construction, the Department of Natural Resources Regional Office serving the area in which the well will be located shall be consulted regarding a proposed well location as it relates to the required separation between existing and potential sources of contamination and groundwater development.
b. The Department of Natural Resources' Geological Survey and Resource Assessment Division shall be consulted prior to design and construction regarding a proposed well location as it relates to required well depth and casing depth, for consolidated formations.

3.2.3.2. Isolation standards.

a. Unless the geology and aquifer hydraulics dictate greater or lesser distances, or unless the department approves a lesser distance based on the engineering report, acceptance of the well site, for new wells, shall be based on compliance with the radii in Table 2.

Figure 2 - New Well Isolation Radii

Source of Possible Contamination	**Minimum Isolation Radius**
Wastewater treatment plants, wastewater lagoons, chemical storage, landfills, petroleum storage tanks, or wastewater and solid waste disposal fields	300 feet
Manure storage area, unplugged abandoned well, graves, subsurface disposal field, sewage pumping station, building or yard used for livestock or poultry, privy, cesspool, or other contaminants that may drain into the soil	100 feet
Sanitary sewer lines, existing wells, pits sumps or holes, septic tanks, lakes or streams	50 feet
The right-of-way of federal, state, or county road	10 feet

b. Source water protection
(1) The owner of the well should control or own all the land within an isolation radius to the extent necessary to maintain minimum distances from potential sources of contamination after the well is constructed.
(2) The owner of the well should adopt a wellhead protection program and should encourage adjacent landowners to adopt voluntary restrictions on land use.
(3) Where legal authorities (such as a city council or county zoning authority) exist to provide ordinances, covenants, zoning, or other legally binding restrictions, the owner of the well should make every feasible effort to obtain legally binding restrictions to control or own all the land within an isolation radius to the extent necessary to maintain minimum distances from potential sources of contamination after the well is constructed.

c. Wells in unconsolidated formation will require greater isolation radii.

d. A well shall be located at least three feet horizontally from a building or any projection, except for a pumphouse.

e. No well shall be located within 15 feet of an overhead electric distribution line or 25 feet from an electric transmission line that is in excess of 50 kilovolts (kV) except for the underground electrical service line in the vicinity of an existing well or proposed well. Where there is a question of the voltage in an electric line, the 25-foot distance should be observed, or where less distance is required the utility company should be consulted for their recommendation for safe distances.

3.2.3.3. Other site location and security considerations.

a. The well shall be so located that the site will meet the requirements for sanitary protection of water as well as protection against fire, flood, vandalism, terrorist acts, or other hazards.

b. The well shall be elevated to a minimum of four feet above the 100-year return frequency flood elevation or four feet above the highest historical flood elevation, which ever is higher, or protected to such elevations.

c. The top of the upper terminal of the well shall be readily accessible to operating and maintenance personnel at all times unless the overall system design allows the well to be out of service for the period of inaccessibility.

d. The area around the well shall be graded to lead surface water drainage away from the well.

3.2.4. Testing and records.

3.2.4.1. Yield and drawdown tests.

Water discharged during a pumping test shall be conducted to the nearest surface water body, storm sewer or ditch in a manner that prevents property damage and that prevents re-circulation of discharged water into the aquifer being pumped.

3.2.4.1.1. For wells in consolidated formations, tests shall:

a. Be performed on every production well after construction or subsequent treatment and prior to placement of the permanent pump (wells in consolidated formations having a nominal casing diameter of less than eight inches may be exempted as approved by the department on a case by case basis);

b. Have the test methods clearly indicated in specifications;

c. Have a test pump capacity, at maximum anticipated drawdown, at least 1.5 times the quantity anticipated;

d. Provide for continuous pumping for at least 24 hours or until stabilized drawdown has continued for at least one hour when test pumped at 1.5 times the design pumping rate; other pumping test methods may be used if prior approval from the department is obtained;

e. Provide the following data:

1. Test pump capacity vs. head characteristics;
2. Static water level;
3. Depth of test pump setting; and
4. Time of starting and ending each test cycle; and

f. Provide recordings and graphic evaluation of the following at one-hour intervals or less as may be required by the department:

1. Pumping rate;
2. Pumping water level;
3. Drawdown; and
4. Water recovery rate and levels.

3.2.4.1.2. For wells in unconsolidated formations, yield and drawdown tests must produce the data necessary to determine the capacity of the well, aquifer characteristics, well efficiency, pumping rates, required distances between wells, pump installation depth settings and other factors that will be of value in the long term operation and maintenance of the well. These comprehensive tests require a minimum of one or two observation wells located 100 to 300 feet from the production well and at the same depth. Yield and drawdown tests shall:

1. Be done on every production well after construction but before placement of the permanent pump;
2. Be done using a pump with a capacity, at maximum anticipated drawdown, at least 1.5 times the quantity anticipated. Bailing, air blowing or air lifting shall not be used;
3. Be done using an accurate rate-of-flow, orifice or venturi meter;
4. Provide for measurement of water levels using either the airline method or the electric sonde method;
5. Be done according to one of the following methods:
   i. The Variable Rate Method: This method is done by setting the pump at the lowest producing zone and pumping at 1.5 times the design rate of the well until the pump breaks suction. If the pump does not break suction for a period of 24-hours, the test shall be completed as a continuous rate test. If the pump breaks suction, the rate shall be slowly decreased until the pumping level stabilizes approximately two feet above the pump intake for at least five minutes. Then the pumping rate shall be decreased 5% and the well pumped until the pumping level stabilizes for one hour. The pumping level shall be measured according to the following schedule:
      0 to 10 minutes - every minute;
      10 to 45 minutes - every 5 minutes;
      45 to 90 minutes - every 15 minutes;
      90 to 180 minutes - every 30 minutes;
      180 minutes to the end of the test - hourly.
      The discharge rate and drawdown thus established shall then be maintained for at least four hours.

This pumping rate shall be considered the available production rate of the well and the observed pumping level during the test shall be considered the production pumping level. The static water level shall be established before the start of the pumping test;

ii. The Constant Rate Method: This method is done by pumping the well at a discharge rate that is 1.5 times the design rate of the well with the test pump intake set five feet below the estimated lowest pumping level. Discharge shall be maintained within plus or minus 5% percent of this flow and shall be checked every ten minutes during the first hour of the test and at 30 minute intervals thereafter. The well shall be pumped for 24 hours or until the pumping level stabilizes for four hours. The static water level shall be established before the start of the pumping test. The pumping level shall be measured according to the following schedule:
0 to 1 minutes - every minute;
10 to 45 minutes - every 5 minutes;
45 to 90 minutes - every 15 minutes;
90 to 180 minutes - every 30 minutes;
180 minutes to the end of the test - hourly.
On completion of the pumping, recovery measurements shall be made according to this same schedule until full recovery is reached or the level stabilizes for at least four hours;

iii. The Step Continuous Composite Method: This method is done by setting the pump at the lowest producing zone and pumping the well at rates ½, ¾, 1, and 1½ times its design capacity. Discharge shall be maintained within plus or minus 5% percent of the designated flow. The static water level shall be established before the start of the pumping test. Measurements of pumping rate and water level shall be made every one minute for the first ten minutes of the test, every two minutes for the next ten minutes, every five minutes for the next 40 minutes, every 15 minutes for the next hour, every 30 minutes fort the next three hours, and hourly for the remainder of the pumping period. At each rate step, the well shall be pumped until the pumping level stabilizes for at least four hours or the pump breaks suction. Water level in the well shall be allowed to recover to static or stabilize for one hour after each pumping step. After each increase in pumping rate the above measurement schedule shall be repeated. On completion of the pumping, recovery measurements shall be made according to this same schedule until full recovery is reached or the level stabilizes for at least four hours; or

iv. Aborted Test: Whenever continuous pumping at a uniform rate is specified, failure of the pump operation for a period greater than one percent of the elapsed pumping time shall require suspension of the test until the water level in the pumped well has recovered to its original level. If the water level does not recover to its original level, pump testing can resume if three successive water level measurements spaced 20 minutes apart show no rise in level; and

f. Provide written records and graphic evaluations of all times, static water levels, pumping rates, pumping water levels, drawdown, and water recovery rates and levels measured.

3.2.4.2. Geological data.

a. Geological data shall be determined from samples collected at five-foot intervals and at each pronounced change in formation.

b. For wells drilled in consolidated material, geological data shall be recorded and samples submitted to the Geological Survey and Resource Assessment Division.

c. For wells drilled into unconsolidated material, a detailed driller's log of all wells and test holes associated with the public well shall be submitted in duplicate to the Public Drinking Water Program.

d. Geological data shall be supplemented with information on drill hole diameters and depths, assembled order of size and length of casing**,** screens and liners; grouting depths; formations penetrated, water levels, and location of any blast charges.

3.2.5. General well construction.

3.2.5.1. Minimum protected depths.

Minimum protected depths of drilled wells shall provide watertight construction to such depth as may be required by the department.

3.2.5.2. Special conditions for wells drilled into consolidated formations.

The depth of the permanent casing will be determined from the examination of drill cuttings by the Geological Survey and Resource Assessment Division.

3.2.5.3. Special conditions for wells drilled into unconsolidated formations.

a. If clay or hard pan is encountered above the water bearing formation, the permanent casing and grout shall extend through such materials but shall not extend any less than 20 feet below the original ground elevation.
b. If a sand or gravel aquifer is overlaid only by permeable soils, the permanent casing and grout shall extend to at least 20 feet below the original or final ground elevation, whichever is lower.
c. If a temporary or a surface casing is used, it shall be completely withdrawn as grout is applied. If the temporary or surface casing cannot be withdrawn, the driller must contact the appropriate department regional office for approval of a method to finish the well.

3.2.5.4. Drilling fluids and additives.

Drilling fluids and additives shall:

a. Not impart any toxic substances to the water or promote bacterial contamination;
b. Be acceptable to the department;
c. Shall be capable of being removed from the drill hole and formation so that they do not retard the capacity of the well; and
d. Use water for preparation that will not contaminate the aquifer.

3.2.5.5. Surface steel casing.

Surface steel casing used for construction shall be capable of withstanding the structural load imposed during its installation and removal.

3.2.5.6. Permanent steel casing pipe.

Permanent steel casing pipe shall:

a. Be new pipe meeting AWWA Standard A-100, or ASTM or API specifications for water well construction;
b. Have minimum weights and thickness indicated in Table 3;
c. Have additional thickness and weight if minimum thickness is not considered sufficient to assure the reasonable life expectancy of a well;
d. Be capable of withstanding forces to which it is subjected; and
e. Have full circumferential welds or threaded coupling joints.

3.2.5.7. Gravel pack material.

a. Gravel pack materials shall:
    1. Be sized based on sieve analysis of the formation and copies of

sieve analyses of the water bearing formation and of the proposed gravel pack shall be submitted to the department for approval before the installing the gravel pack;

2. Be well-rounded particles, 95 percent siliceous material, that are smooth and uniform, free of foreign material, properly sized, washed and then disinfected immediately prior to or during placement;
3. Have an average specific gravity of not less than 2.5;
4. Have uniformity coefficient not to exceed 2.5;
5. Have a gravel pack-to-formation sand ratio within the range of 6:1 to 4:1; and
6. Be disinfected with at least a 200 milligrams per liter chlorine solution, just before installation.

b. Gravel pack.

1. Gravel pack shall be placed in one continuous operation.
2. The annular space between the well screen and the hole shall be at least four inches to allow proper placement of gravel pack.
3. Gravel refill pipes, when used, shall be Schedule 40 steel pipe incorporated within the pump foundation and terminated with screwed or welded caps at least 12 inches above the pumphouse floor.
4. Gravel refill pipes located in the grouted annular opening shall be surrounded by a minimum of 1 1/2 inches of grout.
5. Gravel pack shall extend at least 20 feet above the well screen.
6. Protection from leakage of grout into the gravel pack or screen shall be provided.
7. Permanent inner casing and outer casings shall meet requirements of subparagraphs 3.2.5.5. and 6.

3.2.5.8. Packers.

Packers shall be of material that will not impart taste, odor, toxic substance or bacterial contamination to the well water. Lead packers shall not be used.

3.2.5.9. Screens.

Screens shall:

a. Be constructed of stainless steel;

b. Have size of openings based on sieve analysis of formation and/or gravel pack materials. Copies of sieve analyses of the water bearing formation and of the proposed gravel pack shall be submitted to the department for approval before the size of the screen is specified;

c. Have sufficient diameter and length to provide adequate specific capacity and a lower entrance velocity not to exceed 0.1 foot per second. Lower entrance velocity is recommended for water of significant incrustating potential;

d. Be installed so that the pumping water level remains above the screen under all operating conditions;

e. Where applicable, be designed and installed to permit removal or replacement without adversely affecting watertight construction of the well;

f. Be provided with a bottom plate or washdown bottom fitting of the same material as the screen**;** and

g. Be capable of resisting the column and tensile loads and the collapse pressures imposed during installation and well development and imposed by the external geological forces**.**

3.2.5.10. Plumbness and alignment requirements.

a. Every well shall be tested for plumbness and alignment in accordance with the latest edition of AWWA Standard A-100.

b. The test method and allowable tolerance shall be clearly stated in the specifications.

c. If the well fails to meet these requirements, it may be accepted by the engineer**,** after consultation with the department**,** if it does not interfere with the installation or operation of the pump or uniform placement of grout.

3.2.5.11. Grouting requirements.

a. All permanent well casings shall be surrounded by a minimum of 1½ inches of grout to the depth required by the department**.** Grouting consists of filling the annular space between the permanent casing and the drill hole with impervious material. Grouting is necessary to protect water-bearing aquifers from contamination, to prevent unwanted water movement between aquifers and to preserve or protect the hydraulic response of the water producing zones**.**

b. Grout materials shall consist of Portland cement conforming to the latest AWWA Standard and water, with not more than six gallons of water per sack (94 pounds**)** of cement

c. Additives may be used to increase fluidity of grout materials or to bridge voids, subject to prior approval by the department.

d. Application.

   1. Sufficient annular opening shall be provided to permit a minimum of 1 1/2 inches of grout around permanent casings, including couplings.

   2. Prior to grouting through creviced or fractured formations, bentonite or similar materials may be added to the annular opening, in the manner indicated for grouting.

   3. Before placing the grout, water or other drilling fluid shall

be circulated in the annular space sufficient to clear obstructions.

4. When grouting a well, one of the following methods shall be used:

   1. The Positive-Placement Interior Method: When the annular opening is less than three inches (the diameter of the drill hole is less than six inches larger than the casing diameter), grout shall be installed using the positive-placement interior method. This method involves introducing the grout through the well casing or a pipe inside the well casing. Either an expandable or drillable plug shall be installed at the bottom of the well casing and the grout pipe shall extend through this plug. Then grout shall be installed under pressure by means of a grout pump from the bottom of the annular opening upward in one continuous operation until the annular opening is filled. If the grout does not reach the surface, the driller shall wait at least 24 hours and then determine the elevation of the top of the grout. The appropriate Department of Natural Resources Regional Office shall be contacted for approval of the method used to complete grouting of the well by using the tremie method;
   2. The Positive-Placement Exterior Method: When the annular opening is three or more inches (the diameter of the drill hole is six inches or more larger than the casing diameter) and less than 300 feet in depth, grout may be placed by the positive-placement exterior method. This method requires pumping grout through a grout pipe installed in the annular opening. The maximum diameter of the grout pipe shall be at least 1½-inches smaller than the annular opening. The grout shall be placed to the bottom of the annular opening in one continuous operation until the annular opening is filled. The grout pipe shall be raised as the grout is placed but the discharge end of the grout pipe must be submerged in the placement grout at all times until grouting is complete. The grout pipe shall be maintained full, to the surface, at all times until grouting is complete. In case of interruption of grouting operations, the grout pipe must be removed from the drill hole and all air and water displaced from the grout pipe and the pipe flushed clean with clear water. After the grout pipe is cleaned, it may be placed in the drill hole and grouting resumed; or
   3. The Tremie Method: When the annular opening is four

or more inches (the diameter of the drill hole is eight inches or more larger than the casing diameter) and less than 100 feet in depth, grout may be placed by gravity through a tremie pipe. The tremie pipe shall be installed to the bottom of the annular opening and the grout placed in one continuous operation until the annular opening is filled. The tremie pipe shall be raised as the grout is placed but the discharge end of the pipe must be submerged in the placement grout at all times until grouting is complete. The tremie pipe shall be maintained full, to the surface, at all times until grouting is complete. The maximum diameter of the tremie pipe shall be at least 1½-inches smaller than the annular opening.

5. After grouting is applied, work on the well shall be discontinued for at least 72 hours or until the grout has set properly.

e. Guides.

1. The casing must be provided with sufficient guides welded to the casing to permit unobstructed flow and uniform thickness of grout.
2. Spacer guides shall be provided at the bottom, at the top, and along the entire length of the casing at 100 foot intervals.

3.2.5.12. Upper terminal well construction.

a. Permanent casing for all groundwater sources shall project at least 12 inches above the pumphouse floor or concrete apron surface and at least 18 inches above final ground surface.

b. Where a vertical turbine pump is provided for the well, the pumphouse must have forced ventilation of at least six changes of air per hour.

c. The top of the well casing at sites subject to flooding shall terminate at least four feet above the 100 year level or the highest known flood elevation, whichever is higher, or as the department directs.

3.2.5.13. Development.

a. Practically all drilling methods cause compaction of unconsolidated materials in an annulus of variable thickness about a drill hole. In consolidated formations, similar compaction may occur in some poorly cemented rocks. In addition, fines are driven into the wall of the hole, drilling mud invasion may occur, and a mud cake may form on the wall of a hole. Proper well development breaks down the compacted drill hole wall, liquefies jelled mud, and draws it and fines into the well where they can be removed. Therefore, every well should be developed and the well construction specifications should include the well development methods to be used.

b. Every well drilled into an unconsolidated formation shall be developed by surging and bailing or surging and pumping. The surging shall be done using a single or double solid or valved surge block. Surging shall start at the lowest screen in the well and proceed upwards. Pumping shall be done through the surge block by incorporating suction pipe in the fabrication of the block and shall be done simultaneously with surging. Other methods of development may be considered on a case by case basis and must be specifically approved by the department before use.

c. The approval of the department is required before doing any chemical washing of a well with mud dispersing agents, acids or other chemicals.

d. Development shall continue until the maximum specific capacity is obtained from the completed well.

e. The specifications must include a detailed description of the well development methods to be used.

f. Any redevelopment or rehabilitation shall require prior approval from the department.

3.2.5.14. Capping requirements.

a. A continuously welded metal plate or a threaded cap is the preferred method for capping a well. For gravel wall wells that have inner and outer casings, a continuously welded metal plate shall be provided to cap the area between the two casings**.**

b. A properly fitted, firmly driven, solid wooden plug is the minimum acceptable method of temporarily capping a well until pumping equipment is installed.

c. At all times during the progress of work, the contractor shall provide protection to prevent tampering with the well or entrance of foreign materials.

3.2.5.15. Well plugging.

All well plugging shall conform to appropriate standards developed by the Missouri Department of Natural Resources.

3.2.6. Well pumps, discharge piping and appurtenances.

3.2.6.1. Line shaft pumps.

a. Wells equipped with line shaft pumps shall:

1. Have the casing firmly connected to the pump structure or have the casing inserted into a recess extending at least one-half inch into the pump base; and

2. Have the pump foundation and base designed to prevent water from coming into contact with the joint.

b. Avoid the use of oil lubrication. For existing wells with oil-lubricated pumps and new wells where oil lubrication cannot be avoided, only food grade vegetable oil or mineral oil approved by the ANSI/NSF shall be used.

3.2.6.2. Submersible pumps.

Where a submersible pump is used:

a. The top of the casing shall be effectively sealed against the entrance of water under all conditions, including the vibration or movement of conductors or cables;

b. The electric cable from the pump control panel to the well shall be installed in electric conduit and in a manner that it does not create a fall or tripping hazard; and

c. The electrical cable shall be firmly attached to the riser pipe at 20-foot intervals or less.

3.2.6.3. Discharge piping.

a. The discharge piping shall:
   1. Be restrained joint or fusion welded pipe;
   2. Not be solvent welded plastic or galvanized iron pipe;
   3. Be designed so that the friction loss will be low;
   4. Have the control valves and appurtenances located in a pump house and above the pump house floor when an above-ground discharge is provided;
   5. Be protected against the entrance of contamination;
   6. Be equipped with a check valve, a shutoff valve, a pressure gauge, a totaling water meter, and a sampling tap located at a point where positive pressure is maintained;
   7. Where applicable, be equipped with an air release and vacuum relief valve located upstream from the check valve; with exhaust and relief piping terminating in a down-turned position at least 18 inches above the floor and covered with an 18-mesh corrosion resistant screen;
   8 Be valved to permit test pumping and control of each well;
   9. Have all exposed piping, valves and appurtenances protected against physical damage and freezing;
   10. Be properly anchored to prevent movement and be properly supported to prevent excessive bending forces; and
   11. Be protected against surge or water hammer.

b. The discharge piping should be provided with a means of pumping to waste, but shall not be directly connected to a sewer.

3.2.6.4. Pitless well units.

a. The department must be contacted for approval of specific applications of pitless units.

b. Pitless units shall:
   1. Be shop-fabricated from the point of connection with the well casing to the unit cap or cover;
   2. Be threaded or welded to the well casing;
   3. Be of watertight construction throughout;
   4. Be of materials and weight at least equivalent and compatible to the casing;
   5. Have field connection to the lateral discharge from the pitless unit of threaded, flanged or mechanical joint connection; and
   6. Terminate at least 18 inches above final ground elevation, four feet above the 100-year flood level, or the highest known flood elevation whichever is higher.

c. The design of the pitless unit shall make provision for:
   1. Access to disinfect the well;
   2. A properly constructed casing vent meeting the requirements of this document;
   3. Facilities to measure water levels in the well as specified in this document;
   4. A sanitary well seal at the upper terminal of the unit;
   5. A contamination-proof entrance connection for electrical cable;
   6. An inside diameter as great as that of the well casing; up to and including casing diameters of 12 inches in order to facilitate work and repair on the well, pump or well screen; and
   7. At least one check valve within the well casing or in compliance with requirements of the department.

d. If the connection to the casing is to be welded in the field, shop-assembled unit must be designed specifically for field welding to the casing. The only field welding permitted will be that needed to connect a pitless unit to the casing.

3.2.6.5. Casing vent.

Provisions shall be made for venting to the atmosphere the well casing that houses the well pump. The vent pipe shall be installed into the side of the casing and shall terminate in a downturned position at or above the top of the casing or pitless unit with the opening covered with a 18 mesh, corrosion resistant screen. The pipe connecting the casing to the vent shall be of adequate size to provide rapid venting of the casing but shall not be smaller than 1.5-inches in diameter.

3.2.6.6. Water level measurement.

a. Provisions shall be made for periodic measurement of water levels in the completed wells,

b. Where pneumatic lines are used, water level measuring equipment and accessories shall be provided using corrosion-resistant materials attached firmly to the drop pipe or pump column in such a manner as to prevent entrance of foreign materials.

3.2.6.7. Observation wells.

If they are to remain in service after completion of a water supply well, observation wells shall be constructed in accordance with the requirements for permanent wells and protected at the upper terminal to preclude entrance of foreign materials.

Figure 3 - Steel Pipe

STEEL PIPE					
SIZE (inches)	DIAMETER (inches)		WALL THICKNESS (inches)	WEIGHT (pounds/feet)	
	Outside	Inside		plain ends (calculated)	threads & couplings (nominal)
6 id.	6.625	6.065	0.280	18.97	19.18
8	8.625	7.981	0.322	28.55	29.35
10	10.750	10.020	0.365	40.48	41.85
12	12.750	12.000	0.375	49.56	51.15
14 od.	14.000	13.250	0.375	54.57	57.00
16	16.000	15.250	0.375	62.58	
18	18.000	17.250	0.375	70.59	
20	20.000	19.250	0.375	78.60	
22	22.000	21.000	0.500	114.81	
24	24.000	23.000	0.500	125.49	
26	26.000	25.000	0.500	136.17	
28	28.000	27.000	0.500	146.85	
30	30.000	29.000	0.500	157.53	
32	32.000	31.000	0.500	168.21	
34	34.000	33.000	0.500	178.89	
36	36.000	35.000	0.500	189.57	

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Chapter 4 -- Treatment

4.0. General.

The design of treatment processes and devices shall depend on evaluation of the nature and quality of the particular water to be treated and the desired quality of the finished water.

4.1. Clarification.

Plants using conventional clarification to treat water prior to filtration shall be designed to:

a. Provide at least a two-stage treatment process consisting of primary rapid mixing, flocculation and sedimentation and secondary rapid mixing, flocculation, and sedimentation, in series, to treat surface water;
b. Provide at least a single stage treatment consisting of rapid mix-flocculation-sedimentation for clarification to treat groundwater under the direct influence of surface water**;**
c. Be constructed to permit units to be taken out of service without disrupting operation, and with drains or pumps sized to allow dewatering in a reasonable period of time;
d. Have walls and interior equipment constructed of stainless steel or non-metallic materials or provide duplicate parallel units;
e. Avoid constructing conventional cylindrical settling units because of their excessive short-circuiting and poor flow characteristics;
f. Be started manually following shutdown, unless otherwise approved by the department where automatic monitoring control is provided;
g. Be constructed to minimize hydraulic head losses between units to allow future changes in processes without the need for repumping; and
h. Be piped so raw water cannot be discharged directly into the filters.

4.1.1. Presedimentation, or raw water storage basins.

a. Presedimentation basin is recommended for water systems taking water from navigational rivers.
b. Storage Capacity. Presedimentation basins should be sized so that the river intake can be shut down to allow spill and/or contamination to pass before resuming normal operation**.**
c. Inlet. Incoming water shall be dispersed across the full width of the line of travel as quickly as possible; short-circuiting must be prevented.
d. Bypass. Provisions for bypassing presedimentation basins shall be included.

4.1.2. Rapid Mix.

a. Rapid mix shall mean the rapid dispersion of chemicals throughout the water to be treated, by violent agitation. The engineer shall submit the design basis for the velocity gradient (G-value) selected, taking into consideration the chemicals to be added, water temperature, color, and other water related water quality parameters. Interference between treatment chemicals and the optimum locations and sequences for feeding different chemicals shall be considered in rapid mix design. Multiple rapid mix or chemical injection points may be necessary.

b. Equipment. Basins should be equipped with mechanical mixing devices**.** Static mixing may be considered if the treatment flow is not variable and can be justified by design engineer.

c. Mixing. The detention period shall not be more than 30 seconds at the maximum design flow rate.

d. Location. The rapid mix and flocculation basins shall be as close together as possible. The connecting piping between them shall be designed to prevent chemical buildup.

4.1.3. Flocculation.

a. Flocculation is a process to enhance the collection of smaller floc particles into larger, more easily settleable particles through gentle stirring by hydraulic or mechanical means**.**

b. Basin Design. Inlet and outlet design shall prevent short-circuiting and destruction of floc. A drain and/or pumps shall be provided to handle dewatering and residual removal. Outlets interconnecting the flocculation and sedimentation basins at the bottom must be valved.

c. Detention. The detention time for floc formation shall be at least 30 minutes. The department may consider reduced detention time for ballasted flocculation or for tapered flocculation with diminishing velocity gradient if justified by the engineer.

d. Flow velocity. The velocity of flow through the flocculation basin shall not be less than 0.5 feet per minute nor greater than 1.5 feet per minute.

e. Equipment. Agitators shall be driven by variable speed drives with the peripheral speed of paddles ranging from 0.5 to 3.0 feet per second. Turbine, radial flow type impellers should not be used for flocculation because of their high shear rates. When agitators with axial flow and hydrofoil impellers are used, the designing engineer shall specify the desired velocity gradient (G) range, impeller tip speed, ratio of impeller diameter to equivalent tank diameter and superficial velocity range. The impeller tip speed should not exceed 8 ft/sec for a three or four-blade hydrofoil. The superficial velocity should not be less than 3 ft/min nor greater than 10 ft/min. The ratio of the impeller diameter to equivalent tank diameter should not be less than 0.30 nor larger than 0.45.

f. Piping. Flocculation and sedimentation basins shall be as close together as possible. The velocity of flocculated water through pipes or conduits to settling basins shall be not less than 0.5 feet per second nor greater than 1.5 feet per second. Allowances must be made to minimize turbulence at bends and changes in direction.

g. Other designs. Baffling may be used to provide for flocculation in small plants only after consultation with the department. The design should be such that the velocities and flows noted above will be maintained.

h. Superstructure. A superstructure over the flocculation basins may be required.

4.1.4. Sedimentation.

Sedimentation, a process for removal of solids before filtration by gravity separation, shall follow flocculation. The detention time for effective clarification is dependent upon a number of factors related to basin design and the nature of the raw water. The following criteria apply to conventional sedimentation units:

a. Conventional rectangular settling units shall have a minimum length to width ratio of three to one (3:1) or shall have baffles that will provide a flow path that gives the same ratio;

b. Detention Time. Settling units shall provide a minimum of four hours of settling time. This may be reduced to two hours for lime-soda softening facilities treating only groundwater. The volume that will be used in determining the detention time shall be calculated using the effective dimensions of the basin. The effective length is measured from the inside edge of the last influent weir or launder to the inside edge of the first effluent weir or launder. The effective side water depth is measured from the effluent level of the launders or submerged orifices to the bottom of the basin. The volume above the submerged orifices should not be included when calculating for the detention time. Where a mechanical residuals scraper is not provided and residual storage volume is allocated at the bottom of the basin, the effective side water depth shall be measured above the allocated residual storage. Reduced sedimentation time may be approved when equivalent effective settling is demonstrated;

c. Inlet Devices. Inlets shall be designed to distribute the water equally and at uniform velocities. Open ports, submerged ports, and similar entrance arrangements are required. A baffle should be constructed across the basin close to the inlet and should project several feet below the water surface to dissipate inlet velocities and provide uniform flows across the basin;

d. Outlet Devices. Outlet weirs or submerged orifices shall be designed to maintain velocities suitable for settling in the basin and to minimize short-circuiting. The use of submerged orifices is recommended in order to provide a volume above the orifices for storage when there are fluctuations in flow. Outlet weirs and submerged orifices shall be designed as follows:

   1. The rate of flow over the weirs shall not exceed 20,000 gallons per day per foot of the outlet launder;

    2. Submerged orifices shall be designed to provide an even flow across the launder to prevent excessive water velocities and to minimize headloss;
    3. Submerged orifice launders should not be located lower than three feet below the water surface; and
    4. The entrance velocity through the submerged orifices shall not exceed 0.5 feet per second.

e. Depth of Basin. A minimum side water depth of ten feet must be provided. Where mechanical residuals removal is not provided, additional depth of basin shall be required for residuals storage.

f. Velocity. The velocity through settling basins shall not exceed 0.5 feet per minute. The basins must be designed to minimize short-circuiting. Fixed or adjustable baffles must be provided as necessary to achieve the maximum potential for clarification.

g. Overflow. An overflow weir or pipe designed to establish the maximum water level on top of the filters should be provided. The overflow shall discharge by gravity with a free fall at a location where the discharge will be noted.

h. Superstructure. A superstructure over the sedimentation basins may be required particularly for water systems that may have problems controlling disinfection byproducts. A cover may be provided in lieu of a superstructure if:
    1. Provisions are included for adequate monitoring under all weather conditions;
    2. There is no mechanical equipment in the basin; and
    3. The basin is equipped with a mechanical sludge removal, large access ways shall be provided for maintenance. The access ways shall be sized and located to provide safe ventilation during basin maintenance and allow easy removal and replacement of the mechanical residuals removal equipment.

i. Residuals Collection. Mechanical residuals collection equipment should be provided.

j. Drainage. Basins must be provided with a means for dewatering. Basin bottoms should slope toward the drain not less than one foot in 12 feet where mechanical residuals collection equipment is not required.

k. Flushing Lines. Flushing lines or hydrants shall be provided and must be equipped with backflow prevention devices acceptable to the department.

l. Safety. Permanent ladders or handholds should be provided on the inside walls of basins above the water level. Guardrails should be included. Compliance with other applicable safety requirements, such as OSHA, should be considered.

m. Residuals Removal. Residuals removal design:
    1. Shall have a minimum of three inches in diameter residuals pipes arranged to facilitate cleaning;
    2. Shall prevent clogging particularly at the entrance to residuals withdrawal piping;

3. Shall have valves located outside the tank for accessibility; and
4. Should include provisions for the operator to observe and sample residuals being withdrawn from the unit.

n. Residuals Management. Facilities for residuals handling and disposal shall be reviewed and approved by the Water Pollution Control Program of this department. The required NPDES (National Pollutants Discharge Elimination System) permit(s) must be obtained before constructing or operating the residuals facilities.

4.1.5. Solids Contact Unit.

Units are normally acceptable for combined softening and clarification where water characteristics are not rapidly variable, flow rates are uniform, and operation is continuous. Before considering solids contact as clarifiers without softening, specific approval of the department shall be obtained based on records of turbidity fluctuations, color, temperature, alkalinity, and hardness. Solids contact units may be considered only as primary clarifiers. Clarifiers should be designed for the maximum uniform rate and should be adjustable to changes in flows that are less than the design rate due to changes in water characteristics. Secondary stage treatment by conventional methods must be provided for surface waters. For a single stage treatment, a minimum of two solids contact units in parallel shall be provided or the unit and all its interior equipment shall be made of stainless steel or non-metallic materials.

4.1.5.1. Installation.

Supervision by a representative of the manufacturer shall be provided with regard to all mechanical equipment at the time of installation and initial operation.

4.1.5.2. Operation.

Adequate piping with suitable sampling taps strategically located to permit the collection of water samples and sludge from critical portions of the units shall be provided. Sampling taps shall be provided at the sludge withdrawal level and preferably at every two feet interval from the basin bottom to two feet below the effluent level. The location of the sampling taps shall allow safe and easy access for routine sampling and be provided with facilities for easy cleanup. Before the units are placed in service**,** the following shall be provided for proper operation:

a. A comprehensive operating manual for the unit and its equipment including "as-built" detailed drawings of the unit, equipment and accessories;
b. Training of operating personnel**;**
c. A complete outfit of tools and accessories; and
d. Necessary laboratory equipment.

4.1.5.3. Chemical feed.

a. Chemicals shall be applied at such points and by such means as to ensure satisfactory mixing of the chemicals with the water. Interference between treatment chemicals and optimum locations and sequences for feeding different chemicals shall be considered. Multiple rapid-mixing facilities or chemical injection points may be necessary.
b. Cross-connection control must be provided for the make-up water lines of each chemical**.**
c. All chemicals shall meet AWWA Standards and must be certified for drinking water use under ANSI/NSF Standards 60/61.

4.1.5.4. Rapid mixing.

To ensure proper mixing of applied chemicals, a rapid mixing device or a chamber ahead of solids contact units shall be required for units treating surface water and may be required for units treating other waters. Mixing devices employed shall be constructed to:

a. Provide good mixing of the raw water with previously formed residuals particles; and
b. Prevent deposition of solids in the mixing zone.

4.1.5.5. Flocculation.

Flocculation equipment shall:

a. Be adjustable in speed and/or pitch over a range consistent with the type of raw water being treated and the residuals being developed;
b. Provide for coagulation in a separate chamber or baffled zone within the unit; and
c. Provide at least 30 minutes of flocculation and mixing time.

4.1.5.6. Residuals concentrators.

a. The equipment should provide either internal or external concentrators in order to obtain a concentrated residuals with a minimum of waste water.
b. Large basins should have at least two sumps for collecting residuals with one sump located in the central flocculation zone.

4.1.5.7. Residuals removal.

The residuals removal design shall:

a. Have a minimum of three inches in diameter residuals pipes so arranged to facilitate cleaning;
b. Prevent clogging at the entrance to residuals withdrawal piping;
c. Have valves located outside the tank for accessibility; and

d. Be automatic**.** Timers on automatic valves shall be designed to allow frequency and duration intervals to be set to provide frequent operation for very short intervals. Operation of automatic valves shall provide for fast opening and closing that will be compatible with the required short intervals residuals removal, shall discharge into a facility that is approved and permitted by the Water Pollution Control Program of this department, and should include provisions for the operator to observe and sample residuals being withdrawn from the unit.

4.1.5.8. Cross-connections.

a. Blow-off outlets and drains must terminate and discharge at places satisfactory to the department.
b. Cross-connection control must be included for the potable water lines used to backflush residuals lines.

4.1.5.9. Detention period.

The detention time shall be established on the basis of the raw water characteristics and other local conditions that affect the operation of the unit. Based on design flow rates, the detention time should be:

a. Two and one-half to four hours for suspended solids contact softeners treating surface water; and
b. One and one-half to two hours for the suspended solids contact softeners treating only ground water.

4.1.5.10. Suspended slurry concentrate.

Softening units should be designed so that continuous slurry concentrates of one percent (1%) or more, by weight, can be satisfactorily maintained. In general, softening efficiency improves as suspended slurry concentration increases, although with very high slurry concentration, carry-over is a problem.

4.1.5.11. Water losses.

a. Units shall be provided with suitable controls for residuals withdrawal.
b. The total water losses should not exceed:
    1. Five percent for clarifiers; or
    2. Three percent for softening units.
c. Solids concentration of residuals bled to waste should be--
    1. Three percent by weight for clarifiers; or
    2. Five percent by weight for softeners.

4.1.5.12. Weirs or orifices.

a. The units should be equipped with either overflow weirs or orifices constructed so that water does not travel more than ten feet horizontally to the collection trough.
b. Weirs shall be adjustable, and at least equivalent in length to the perimeter of the tank. However, peripheral weirs are not acceptable as they tend to cause excessive short-circuiting.
c. Weir loading shall not exceed:
    1. Ten gallons per minute per foot of weir length for units used for clarifiers; or
    2. Twenty gallons per minute per foot of weir length for units used for softeners.
d. Where orifices are used, the loading rates per foot of launder should be equivalent to weir loading rates and shall produce uniform rising rates over the entire area of the tank.
e. Weirs and orifices should be at least two feet from the tank wall to minimize carry-over.

4.1.5.13. Upflow rates.

a. The upflow rates shall be determined at the residuals separation line, approximately four feet below the collection weirs or orifices**.**
b. Unless supporting data is submitted to justify higher rates, the upflow rates shall not exceed:
    1. Seventy-five hundredths (0.75) gallon per minute per square foot for units used for clarifiers, or
    2. One (1.0) gallon per minute per square foot for units used for softening.

4.1.6. Tube or plate settlers.

A proposal for settler unit clarification must include pilot plant and/or full-scale demonstration data on water with similar quality prior to the preparation of final plans and specifications for approval. Settler units consisting of variously shaped tubes or plates may be installed in multiple layers at an angle to the flow in the sedimentation basin to enhance settling of solids.

4.1.6.1. General Criteria.

a. Inlet and outlet considerations – The design shall maintain velocities suitable for settling in the basin and minimize short-circuiting.
b. Drainage – Drain piping from the basin must be sized to facilitate a quick flush of the of the settler units and to prevent flooding of

the portions of the plant. Basins should have hopper bottom and residuals removal equipment.

c. Protection from freezing – Outdoor installation must provide sufficient freeboard above the top of the settlers to prevent freezing in the units. A cover or enclosure is strongly recommended.
d. Application rate for tubes – A maximum rate of 2-gpm/square foot of cross-sectional area for tube settlers unless higher rates are successfully shown through pilot plant or in-plant demonstration studies.
e. Application rate for plates – A maximum loading rate of 0.5 gpm/ square foot for plate settlers, based on 80 percent of the projected horizontal plate area.
f. Flushing lines – Flushing lines shall be provided to facilitate maintenance and must be properly protected against backflow or back siphonage.

4.2. Filtration.

Filtration is a process for removing particulate matter from water by passing through porous media. Pretreatment shall be required prior to filtration unless otherwise approved by the department. Acceptable filters shall include the following types: rapid rate gravity filters, rapid rate pressure filters, and membrane filters. Other types of filters maybe considered if justified by the engineer through pilot or full-scale testing. The application of these types of filters must be supported by water quality data representing a reasonable period of time to characterize variations in water quality.

4.2.1. Rapid rate gravity filters.

4.2.1.1. Rate of filtration.

The design rate shall be a maximum of two gallons per minute per square foot of the filter surface area. Higher rates may be considered based on raw water quality, degree of pretreatment provided, type of filter media, water quality control parameters, competency of operating personnel, and other factors as required by the department. In any case, the filter rate must be proposed and justified by the designing engineer to the satisfaction of the department prior to the preparation of final plans and specifications.

4.2.1.2. Number.

At least two units shall be provided. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved filtration rate. Where more than two filter units are provided, the filters shall be capable of meeting the plant design capacity at the approved filtration rate with one filter removed from service. Provisions to control the flow into or from each filter and to divide flows equally between each active filter must be provided.

4.2.1.3. Structural details and hydraulics.

The filter structure shall be designed to provide for:

a. Vertical walls within the filter;
b. No protrusion of the filter walls into the filter media;
c. Cover by superstructure (roof drains must not discharge into the filters);
d. Head room to permit normal inspection and operation;
e. Minimum depth of filter box of 8½ feet;
f. Minimum water depth over the surface of the filter media of three feet;
g. Trapped effluent to prevent backflow of air to the bottom of the filters;
h. Prevention of floor drainage to the filter with a minimum four-inch curb around the filters;
i. Prevention of flooding by providing overflow;
j. Maximum velocity of treated water in pipe and conduits to filters of two feet per second;
k. Cleanouts and straight alignment for influent pipes or conduits where solids loading is heavy, or following lime-soda softening;
l. Washwater drain capacity to carry maximum flow;
m. Walkways around filters, to be not less than 24 inches wide;
n. Safety handrails or walls around all filter walkways;
o. Construction to prevent cross connections and common walls between potable and nonpotable water; and
p. Provisions for filtering to waste at normal filtration rates until the turbidity of the filter effluent drops to an acceptable level. An air gap or other backflow prevention assembly shall be provided at the filter-to-waste line. Controls for filtering to waste should be incorporated with the other filter controls.

4.2.1.4. Washwater troughs.

Washwater troughs shall be designed to have:

a. The bottom of the troughs above the maximum level of expanded media during washing;
b. The troughs carry the maximum rate of washwater with a two-inch freeboard;
c. The top edge of the troughs level and all at the same elevation;
d. The troughs spaced so that each trough serves the same number of square feet of filter area; and
e. The maximum horizontal travel of suspended particles to reach the trough not to exceed three feet.

4.2.1.5. Filter material.

a. All filter materials shall meet the current AWWA standards for filtering materials. The media shall be clean silica sand or other natural or synthetic media approved by the department, having the following characteristics:
    1. A total depth of not less than 24 inches and generally not more than 30 inches;
    2. A minimum of 12 inches of media having an effective size range no greater than 0.45 mm to 0.55 mm, and specific gravity greater than other filtering materials within the filter; and
    3. A uniformity coefficient of the smallest material not greater than 1.65.

b. Types of filter media.
    1. Anthracite - Clean crushed anthracite, or a combination of anthracite and other media may be considered on the basis of experimental data specific to the project, and shall have:
        1. Effective size of 0.45 mm - 0.55 mm with uniformity coefficient not greater than 1.65 when used alone,
        2. Effective size of 0.6 mm – 0.8 mm with a uniformity coefficient not greater than 1.85 when used as a cap; and
        3. As an exception, effective size for anthracite used alone on potable groundwater for iron and manganese removal only shall be a maximum of 0.8 mm (effective sizes greater than 0.8 mm may be approved based upon onsite pilot plant studies).
    2. Sand. Filter sand shall have an effective size of 0.45 mm to 0.55 mm and a uniformity coefficient of not greater than 1.65.
    3. Granular Activated Carbon (GAC) – Granular activated carbon as a single media may be considered for filtration only after pilot or full-scale testing. The design shall include the following:
        1. The media must meet the basic specifications for filter media in this section. Larger size may be allowed where pilot or full-scale tests have demonstrated that treatment goals can be met under all conditions;
        2. There must be provisions for a chlorine residual and adequate contact time in the water following filters and prior to distribution;
        3. There must be means for periodic treatment of filter material for control of bacterial and other growth; and
        4. Provisions must be made for frequent replacement or regeneration.
    4. Other filter media – Other media will be considered based on experimental data and operating experience.

c. Torpedo sand - A three-inch layer of torpedo sand shall be used as a supporting media for filter media, and should have:
    1. Effective size of 0.8 mm to 2.0 mm; and

2. Uniformity coefficient not greater than 1.7.

d. Gravel.

1. Gravel, when used as the supporting media shall consist of cleaned and washed hard, durable, rounded silica particles and shall not include flat or elongated particles. The minimum thickness of each gravel layer shall not be less than twice the size of the biggest possible particle. The coarsest gravel shall be 2 1/2 inches in size when the gravel rests directly on a lateral system, and must extend above the top of the perforated laterals. A minimum of four layers of gravel shall be provided in accordance with the following size and depth distribution:

Size	**Depth**
2 1/2 to 1 1/2 inches	5 to 8 inches
1 1/2 to 3/4 inches	3 to 5 inches
3/4 to 1/2 inches	3 to 5 inches
1/2 to 3/16 inches	2 to 3 inches
3/16 to 3/32 inches	2 to 3 inches

2. Reduction of gravel depths, number of layers and size gradations may be considered upon justification to the department by showing conformance to AWWA standards when proprietary filter bottoms are specified.

4.2.1.6. Filter bottoms and strainer systems.

Departures from these standards may be acceptable for high rate filters and for proprietary bottoms. Porous plate bottoms shall not be used where iron or manganese or hardness precipitation may clog them or with waters softened by lime. The manifold-type collection systems shall be designed to:

a. Minimize loss of head in the manifold and laterals;

b. Ensure an even distribution of washwater and an even rate of filtration over the entire area of the filter,

c. Provide the ratio for the area of the final openings of the strainer systems to the area of the filter at about 0.003,

d. Provide the total cross-sectional area of the laterals at about twice the total area of the final openings,

e. Provide the cross-sectional area of the manifold at 1½ to 2 times the total area of the laterals;

f. Provide spacing of the laterals not to exceed 12 inches; and

g. Provide spacing of the perforations along the lateral not to exceed eight inches.

4.2.1.7. Surface wash or subsurface wash.

Surface wash facilities are required except for pressure filters or where air scour is used. A 1½ -inch to 2-inch pressure line must be located conveniently on the filter plant operating floor and equipped with suitable lengths of 1-inch to 1½-inch pressure hose and nozzle. A suitable rack should be available for storing the hose. Auxiliary surface or subsurface wash may be accomplished by a system of fixed nozzles or a revolving type apparatus. All devices shall be designed with:

a. Provisions for water pressures of at least 45 psi;
b. A properly installed backflow prevention assembly to prevent back siphonage if connected to the treated water system; and
c. Rate of flow of 2.0 gallons per minute per square foot of filter area with fixed nozzles or 0.5 gallons per minute per square foot with revolving arms.

4.2.1.8. Air Scouring.

Air scouring may be considered in place of surface wash based on the following standards:

a. Air scouring controls must allow the operator to control the air and water flow rates and duration. Rate of flow indicators for air and water shall be provided. Provide manual over-ride to the automated backwash controls for backwashing the filters including air scour. Automated backwash controls shall not automatically start filter backwash. Filter backwashing must be initiated manually;
b. Air flow for air scouring the filter must be three to five cubic feet per minute per square foot of filter area when the air is introduced in the underdrain; a lower air rate shall be used when the air scour distribution system is placed above the underdrains;
c. A method for avoiding excessive loss of the filter media during backwashing must be provided;
d. Air scouring should be followed by a fluidization wash to restratify the media;
e. Air must be free from contamination;
f. Air scour distribution system should be placed at or below the media and supporting bed interface; if placed at the interface, the air scour nozzles shall be designed to prevent media from clogging the nozzles or entering the air distribution system;
g. Piping for the air distribution system shall not be flexible hose which may collapse when not under pressure and shall not be relatively soft material which may erode at the orifice opening with the passage of air at high velocity;
h. Air delivery piping shall not pass down through the filter media unless a minimum of two anti-seepage collars, six inches apart are provided in each pipe. The anti-seepage collars shall extend three inches out from the pipe and be continuous around the entire circumference of the pipe. No arrangement in the filter design shall allow short circuiting between the applied unfiltered water and the filtered water;
i. Consideration should be given to maintenance and replacement of air line;

j. During air scour, the backwash water rate must be variable and should not exceed eight gallons per minute per square foot unless operating experience shows that higher rate is necessary to remove scoured particles from the filter media surfaces;

k. The filter underdrain shall be designed to accommodate air scour piping when the piping is installed in the underdrain; and

l. Subparagraph 4.2.1.10 must be followed when backwashing filters.

4.2.1.9. Appurtenances.

a. The following shall be provided for every filter:
   1. Influent and effluent sampling points;
   2. An indicating, and preferably recording, loss of head gauge or transmitter;
   3. An indicating rate-of-flow meter. A rate controller that limits the rate of filtration to a maximum rate through each filter may be used. However, equipment that simply maintains a constant water level on the filters is not acceptable, unless the rate of flow onto the filter is properly controlled. A pump or a control valve or a flow meter in each filter effluent line may be used as the limiting device for the rate of filtration only after consultation with the department;
   4. Influent or effluent controls that distribute plant flows evenly between the filters and limit the flow rate to the maximum allowable rate; and
   5. Provisions for filtering to waste, especially when used in surface water, with appropriate measures for backflow prevention**.**

b. It is recommended the following be provided for every filter:
   1. A continuous turbidity monitoring and recording device for surface water treatment and lime softening plants to monitor filter to waste and filter effluent turbidity,
   2. Wall sleeves providing access to the filter interior at several locations for sampling or pressure sensing.
   3. A minimum 1½ inch pressure hose equipped with shut-off nozzles or valve and storage rack at the operating floor for washing filter walls; and
   4. Turbidity and/or particle monitoring equipment as a means to enhance treatment operation when treating surface waters.

c. When the top of the filter walls are below the pretreatment basin overflow, the filter basins must be provided with overflow piping.

4.2.1.10. Backwash.

Provisions shall be made for washing filters as follows:

a. A minimum backwashing rate of 15 gallons per minute per square foot, consistent with water temperatures and specific gravity of the filter media shall be provided. A rate of 20 gallons per minute per square foot or a rate necessary to provide for a 50 percent expansion of the filter bed is recommended. A reduced rate of 10 gallons per minute per square foot may be acceptable for full depth anthracite or granular activated carbon filter media;

b. Filtered water provided at the required rate by washwater tanks, a washwater pump, from the high service main, or a combination of these;
c. Washwater pumps in duplicate unless an alternate means of obtaining washwater is available and if air scouring is provided, duplicate air compressors/blowers except where water flow is adequate to backwash the filters at the required rates with water alone;
d. Not less than 15 minutes wash of one filter at the design rate of wash;
e. Timer to record total backwash time;
f. A washwater regulator or valve on the main washwater line to obtain the desired rate of filter wash with the washwater valves on the individual filters open wide;
g. A totaling rate-of-flow on the main washwater line, with an indicator so that it can be easily read by the operator during the washing process; and
h. Equipment designed to prevent rapid changes in backwash water flow.

4.2.2. Rapid rate pressure filters.

4.2.2.1. General.

a. The normal use of these filters is for iron and manganese removal. Pressure filters shall not be used in the filtration of surface water or groundwater under the direct influence of surface water or following a lime-soda softening process.
b. The minimum requirements regarding number, rate of filtration, structural details and hydraulics, filter media, etc., for rapid rate gravity filters (subsection 4.2.1.) also applies to pressure filters, where appropriate.

4.2.2.2. Rate of filtration.

The rate of filtration shall not exceed three gallons per minute per square foot of the filter area. Higher rates may be considered based on satisfactory results of pilot or full-scale testing. The filter piping must be arranged as simple as possible to provide for filtration, backwashing and filtering to waste of each filter individually.

4.2.2.3. Details of design.

The filters shall be designed to provide for:

a. Loss of head gauges on the inlet and outlet pipes of each filter;

b. An easily readable meter or flow indicator on each battery of filters. A flow indicator is recommended for each filtering unit where the filter influent or effluent automatically distributes the flow evenly between active filters;

c. Minimum side wall shell height of six feet. A corresponding reduction in sidewall height is acceptable where proprietary bottoms permit reduction of the gravel depth;

d. The top of the washwater collectors to be at least 18 inches above the surface of the media;

e. The underdrain system to efficiently collect the filtered water and to uniformly distribute the backwash water at a rate not less than 20 gallons per minute per square foot of filter area;

f. Backwash flow indicators and controls that are easily readable while operating the control valves for filter effluent piping that exits the filter below the top of the underdrain. Filter effluent piping shall not extend above the underdrain inside the filter;

g. An air release valve on the highest point of each filter;

h. At least a 24-inch diameter accessible manhole to facilitate inspection, repairs and removal of filter media for filters 36 inches or more in diameter. Sufficient manholes shall be provided for filters less than 36 inches in diameter**;**

i. Means to observe the wastewater during backwashing; and

j. Construction to prevent cross-connection.

4.3. Membrane Filtration Design.

Four categories of membrane filtration are generally recognized. They are microfiltration, ultrafiltration, nanofiltration and reverse osmosis. One can find a number of definitions for these categories but for the purposes of this design standard they are set strictly by membrane pore size and are as follows. Microfiltration covers a pore size range of 0.1 to 2.0 microns. Ultrafiltration covers a pore size range of 0.01 to 0.1 microns. Nanofiltration covers a pore size range of 0.001 to 0.01 microns. Reverse Osmosis covers a pore size range of 0.0001 to 0.001 microns. Using these definitions means that microfiltration does not remove microbiological contaminants and that only nanofiltration and reverse osmosis provide virus removal.

4.3.1. Membrane filtration performance.

Membrane filtration performance is highly site specific. Therefore, pilot studies shall be done to assure that an acceptable quality finished water will be produced through all the source water seasonal quality variations. The selection of membrane treatment shall be determined by source water quality characteristics, treated water quality requirements, the targeted materials to be removed, membrane pore size, molecular weight cutoff, membrane materials and system treatment configuration. All membranes must be certified by the National Sanitation Foundation International. (NSF) to contain no leachable surfactants or other chemicals. When membrane filtration is proposed for removal of microbial contaminants, the membrane used must be certified by the NSF to remove the contaminants expected.

4.3.2. Membrane Filtration.

Pretreatment is required for all types of membrane filtration, to assure removal of color, tastes and odors, to control membrane fouling and to assure useful membrane lives. The type of pretreatment required depends on the characteristics of the source water and the type of membrane filtration selected.

4.3.2.1. Source water testing.

Extensive testing of the source water for all parameters that may affect membrane filtration and finished water quality shall be done.

4.3.2.2. Seasonal source water variation.

Since the source water quality may vary seasonally, sampling shall cover at least one full year.

4.3.2.3. Water quality extremes.

Historic information shall be reviewed to determine water quality extremes that may be expected.

4.3.2.4. Test results.

Tabulated results of tests done and summaries and conclusions shall be submitted as a part of the engineering report proposing membrane filtration.

4.3.3. Design Flux.

Design flux is the volume of water that can move through a given area of membrane in a given time, usually measured in gallons per square foot per day (gfd). The type of membrane material, the characteristics of the raw water, operating pressures, degree of pretreatment, the style of membrane, etc., determine design flux. Information on each of these parameters shall be provided in submittals to the department. Reverse osmosis design should provide for a flux of at least 15 gfd. Microfiltration design fluxes average around 70 gfd. Nanofiltration and ultrafiltration design fluxes fall proportionally in-between. The flux used to design a specific installation depends on the purpose of the installation and the degree of system integrity required. The greater the number of membrane fibers required to produce a given output of water the smaller the impact of bypass flow from a single break. Thus, for removal of microbial contaminants, lower than average design fluxes should be used. Justification for the design flux used shall be provided in the submittal to the department.

4.3.4. Design Pressure Drop or Transmembrane Pressure.

Design pressure drop or transmembrane pressure is the pressure differential range required across the membrane to produce at the design flux for a normal filter run. Large pressure differentials require high influent pressures, increase operating costs, and shorten membrane life. Also, bypass flow from membrane fiber breakage is proportional to the pressure differential across the membrane. Pretreatment and membrane selection shall be done to provide the lowest practical design pressure drop.

4.3.5. Membrane Fouling.

Fouling and scaling characteristics of the source water and design cleaning frequency shall be considered. Design shall include provisions for minimizing membrane fouling.

4.3.5.1. System integrity.

System integrity and reliability shall be considered in the design. Multiple membrane arrays, skids or trains shall be provided. The treatment system shall be able to meet design maximum design flows while one membrane array, skid or train is isolated for membrane replacement, testing, back washing or cleaning.

4.3.5.2. Membrane design.

Design shall include piping, valves, fittings and other provisions for isolation and easy removal of membrane arrays, skids or trains and of individual membrane modules for replacement, testing, backwashing and cleaning.

4.3.5.3. Direct testing equipment.

Equipment for direct testing shall be provided to monitor membrane integrity and to detect and locate defects or breaches that could allow feed water to bypass membrane filtration. Direct testing equipment shall include but not be limited to equipment for bubble testing and conducting pressure or vacuum hold testing of membrane modules.

4.3.5.4. Membrane backwashing and air filtration.

Provisions for backwashing the membranes shall be provided. Since backwashing is frequent, duplication of equipment is necessary to assure continuous plant operation. If pressure air is used, the air compressors shall not impart oil into the compressed air. Furthermore, air filtration shall be provided to assure that the membranes are not contaminated with airborne pathogens.

4.3.5.5. Chemical cleaning.

Equipment and appurtenances necessary for chemical cleaning of the membranes shall be provided.

4.3.6. Membrane Rating.

Membranes rated by pore size can be either nominal or absolute. Nominally rated membranes must be rated at the size on their particle retention curve where the membrane retains 98% of that size particles. Absolute rated membranes must retain 100% of particles that are the same size as the pore size rating of the membrane. Specifications shall clearly state whether membrane pore size is nominal or absolute. Nominal size membranes shall be followed by additional treatment.

4.3.7. Recovery.

Recovery is the amount of finished treated water produced from a given amount of feed water. Design percent recovery should be more than 80%.

4.3.8. Membrane Filtration Design.

The following shall be addressed in membrane filtration design:

a. Redundancy of membrane arrays, skids or trains shall be provided sufficient to meet maximum design flow at the highest expected design pressure drops and lowest expected temperatures of the water to be treated.

b. The design shall provide for plugging off and replacing failed membrane fibers. The necessary equipment, valves, piping and appurtenances shall be provided to easily shut off individual membrane modules and to locate and remove defective fibers;

c. The design shall provide for pressure gauges on the influent and effluent piping to each membrane array, skid or train. Preferably these pressures should be measured by pressure transducers with digital read outs and continuous recorders. At a minimum, the gauges shall be 4½-inch diameter, liquid filled, sealed gauges correct to within ½ of 1% of full scale;

d. Online particle sizing and counting equipment shall be provided on the effluent piping of each membrane array, skid or train. Turbidity monitoring equipment shall be provided for on the influent and effluent piping of the membrane arrays, skids or trains. Continuous recording equipment shall be provided for turbidity and for the particle counts in the 2 to 5 micron range. This equipment shall connect with an alarm system to warn operators of excessive particle or turbidity break-through; and

e. Design life of the membranes should be greater than four years.

4.3.9. Flow Meters.

Totaling rate of flow meters shall be provided on the source water influent piping, the plant finished water piping, on membrane backwash piping, on plant water use piping and on cross-circulation or retentate piping.

4.3.10. Post Treatment.

Post treatment shall be provided for neutralization of aggressive water, disinfection with the required contact time, and maintenance of distribution system disinfectant residuals.

4.3.11. Waste Disposal.

Provision shall be made for disposing of chemical cleaning and other wastes generated by membrane filtration for compliance with requirements in 10 CSR 20.

4.4. Disinfection.

Requirements for disinfection and disinfection residuals are found in 10 CSR 60-4.055 Disinfection Requirements. Disinfection by-products are regulated pursuant to 10 CSR 60-4.090. Maximum Contaminant Levels and Monitoring Requirements for Disinfection By-Products.

Chlorine is the preferred disinfecting agent. Disinfection may be accomplished with liquid chlorine, calcium or sodium hypochlorite, chlorine dioxide, or ozone**.** Other disinfecting agents will be considered, provided reliable application equipment is available and testing procedures for a residual are recognized in the latest edition of "Standard Methods for the Examination of Water and Wastewater." Disinfection is required at all surface water supplies and at any ground water supply of questionable sanitary quality or where other treatment is provided. Continuous disinfection is recommended for all water supplies. Disinfection with chloramines is not recommended for primary disinfection to meet the CT requirements in a surface water treatment plant or a plant treating groundwater under the influence of surface water. In a conventional filtration treatment plant, softening plant, and iron and manganese removal plant, provisions should be made for applying disinfectant to the influent of each sedimentation basin, filter influent, and water entering the clearwell. Chlorine dioxide shall not be used as distribution system disinfection. Systems using chloramines as the disinfectant residual entering the distribution system must add and mix the chlorine prior to the addition of ammonia.

4.4.1. Contact time and point of application.

a. Due consideration shall be given to the contact time of the disinfectant in water with relation to pH, ammonia, taste-producing substances, temperature, bacterial quality, disinfection by-products formation potential and other pertinent factors. Disinfectant shall be applied at a point that will provide adequate contact time. All required disinfectant contact time should be provided after filtration. All basins used for disinfection must be designed to minimize short-circuiting.

b. For surface water systems and ground water systems under the direct influence of surface water:

1. The disinfectant contact time must be determined by Tracer Studies as explained in Appendix B of the “Guidance Manual for Surface Water System Treatment Requirements.” The tracer study is required for a new treatment plant prior to receiving final approval from the department for permission to operate;
2. The disinfection treatment must provide a sufficient CT (Disinfectant residual concentration multiplied by the contact time) value to ensure that the total treatment process achieves the required inactivation and/or removal of *Giardia lamblia* cysts and viruses. The percentage of *Giardia lamblia* cyst and virus removal by the disinfection process shall be determined by calculating the CT value and comparing the calculated CT value with the corresponding water characteristics on the CT tables in Appendix C of the Guidance Manual for Surface Water System Treatment Requirements; and
3. Free residual chlorination is the preferred practice. If the system uses a disinfectant other than chlorine, the system must demonstrate to the department that the treatment process can satisfactorily inactivate and/or provide the required log removal of *Giardia lamblia* cysts and viruses.

c. For groundwater systems, the disinfection treatment must provide a sufficient CT value to ensure that the total treatment process achieves the required inactivation and /or removal of viruses. Free residual chlorination is the preferred practice.

4.4.2. Residual disinfectant.

a. Only free available chlorine or chloramine shall be used as the disinfectant to water entering the distribution system. Chlorine or chloramine shall be applied prior to the filters with a residual maintained through the filters, to the water entering the distribution system, and at distant points in the water distribution system. Chloramine, when used as the disinfectant, must provide breakpoint chlorination in the treatment process before converting the chlorine to chloramine.

b. The minimum disinfectant residual of water entering the distribution system shall be 1.0 milligrams per liter of free available chlorine or 2.0 milligrams per liter chloramine.

c. Minimum free residual at distant points in a water distribution system shall be 0.5 milligrams per liter. Chloramine residual, if utilized, shall be 1.0 milligrams per liter at distant points in the distribution system.

4.4.3 Testing equipment.

Chlorine residual test equipment shall meet the requirements established in 10 CSR 60-5.010 and shall be capable of measuring residuals to the nearest 0.2 milligram per liter**.** All treatment plants serving a population greater than 3,300 shall be equipped with recording chlorine analyzers monitoring water entering the distribution system.

4.4.4 Other Disinfecting Agents.

Although disinfecting agents other than chlorine are available, each has usually demonstrated shortcomings when applied to a public water supply. Proposals for use of disinfecting agents other than chlorine, including ozone disinfectant, must be approved by the department prior to preparation of final plans and specifications.

4.4.5. Ozone Disinfectant.

4.4.5.1. Bench scale studies.

Prior to the use of ozone for primary disinfectant, bench scale studies must be conducted for ground water sources and full scale pilot studies must be conducted for surface water and ground water under the influence of surface water sources.

4.4.5.2. Chief operators.

Chief operators for water systems treating water with ozone must have the appropriate operator certification level required by the operator certification rules in 10 CSR 60-14.

4.4.5.3. Disinfectant residual.

Systems utilizing ozone for the primary disinfectant must provide for maintaining a residual of chlorine or chloramine in the distribution system.

4.4.6. Disinfection Byproduct and Precurser Removal and Control

Disinfection byproducts are formed when disinfectants react~~s~~ with naturally occurring organic substances. These organic substances, called "precursors," are a complex and variable mixture of compounds. Formation of disinfection byproducts is dependent on such factors as amount and type of disinfectant used, temperature, concentration and type of precursor, pH, and contact time.

Pilot or full-scale studies for disinfection byproduct and precursor removal and control shall be performed. Any full plant trial studies or modifications to an existing treatment process shall be pre-approved by the department. Water treatment plants for which construction is begun after the effective date of this document shall be designed with clearwells and other plant finished water storage sized to provide all of the required disinfectant contact time, CT, after filtration. These storage facilities must be baffled or otherwise designed to assure optimum detention and calculations submitted to support the basis of the design.

4.4.6.1. Methods of controlling precursors at the source.

a. Selective withdrawal from reservoirs. Varying depths may contain lower concentrations of precursors at different times of the year. Analyses for chlorophyll A and B may be useful in selecting withdrawal locations and in controlling plankton.

b. Plankton Control. Algae and their by-products act as disinfection byproduct precursors.

1. Only algaecides approved by the department for use in potable water may be used for algae control in drinking water sources. Equipment for routine sampling and microscopic examination of the source water shall be available to assure that over-treatment does not occur. The minimum equipment must include a microscope with built-in illumination, a Sedgwick-Rafter counting cell, and algae identification manuals**.**
2. Destratification of a water supply reservoir to reduce nutrients and thus plankton growth shall be supported by studies done on similar lakes that have been destratified. Furthermore, consideration shall be given to handling increased plankton growth during the first years of the operation. Watershed conditions that result in continuous high nutrient flow to a reservoir may negate any benefits in disinfection byproduct formation provided by destratification.
3. Alternative sources of better quality water should be considered, where available.

4.4.6.2. Removal of disinfection byproduct precursors and control of disinfection byproduct formation.

Pilot or full-scale studies for disinfection byproduct and precursor removal and control shall be performed. In addition, source water tests that cover at least a full calendar year are necessary to assure that the treatment facilities will handle all source water conditions.

a. Moving the point of chlorination to minimize disinfection byproduct formation.

b. Removal of precursors prior to chlorination by practicing enhanced coagulation or softening and by optimizing treatment processes:

1. Enhanced Coagulation and Softening.
    1. Systems treating surface water or ground water under the direct influence of surface water shall provide conventional water treatment. For surface water, conventional treatment is two stages of treatment provided as: primary rapid mix, flocculation and sedimentation followed by secondary rapid mix, flocculation and sedimentation, operated in series and followed by filtration and disinfection contact storage. For ground water under the direct influence of surface water, conventional treatment is defined as one stage of treatment consisting of secondary rapid mix, flocculation and sedimentation and followed by filtration and disinfection contact storage.
    2. For existing treatment plants exceeding disinfection by-product MCLs or not meeting TOC removal requirements, a complete engineering study of all of the treatment processes shall be done to assure they are operating at their optimum. This study shall include a review of influent and effluent facilities for each treatment basin, evidence of basin short-circuiting, basin sizes and geometry, mixer design and chemicals fed and their efficiency. Modifying existing processes to assure optimum performance shall be considered.
    3. For proposed treatment plants, provide flexibility in chemical application and mixing to optimize treatment. Continuous monitoring and recording equipment shall be provided where appropriate.
2. Adding oxidizing agents such as potassium permanganate, ozone, or chlorine dioxide to reduce the chlorine demand and thus the disinfection byproduct formation. Possible health effects of the byproducts produced by the oxidizing agents must be taken into consideration.
3. Adsorption by powdered activated carbon (PAC). Studies using a variety of powdered carbons should be done to find the dosages required, the best application points and the most effective and least costly carbons. Provisions should be made for adding and mixing the carbon solution before any other treatment chemicals are added and for providing a minimum 20 minute contact time with the water.
4. Lowering the pH to inhibit the reaction rate of chlorine with precursor materials and to improve coagulation and

removal of the precursors. Pilot or full plant trials should be done to determine the chemical processes required to stabilize the water. Noncorrosive finished water is required to meet secondary maximum contaminant levels and to assure compliance with the lead and copper rules in 10 CSR 60-15. Written approval of the department shall be obtained before conducting any full plant trials or changing the treatment process.

5. Using various combinations of treatment to remove disinfection byproduct precursors. Combinations of treatment may be necessary to successfully meet disinfection byproduct standards.

4.4.6.3 Removal of disinfection byproducts.

a. Aeration - by air stripping towers.
b. Adsorption by:
    1. Granular activated carbon (GAC).
        1. Methods shall be provided for monitoring carbon bed performance to determine when the carbon is exhausted for disinfection byproduct removal.
        2. Methods shall be provided for monitoring the carbon beds to assure that microbiological growth in the carbon will not pass into the drinking water. Carbon contacter design shall allow for backwashing or cleaning of the carbon bed to control microbiological growth. Facilities for feeding a disinfectant and for providing disinfection contact time shall be provided following granular activated carbon adsorption facilities.
        3. Carbon shall be chosen to minimize carbon grain breakdown or methods provided to prevent carbon fines from passing into the drinking water.
        4. Consideration shall be given to ease of carbon removal and replacement.
    2. Synthetic Resins.
        1. Any resin proposed shall have NSF certification for use with potable water concerning leaching of chemicals into water.
        2. Methods shall be provided for monitoring resin bed performance to determine when the resin is exhausted for disinfection byproduct removal.
        3. Methods shall be provided for monitoring and controlling microbiological growth in the resin.
        4. Resin shall be chosen to minimize breakdown or methods provided to prevent resin fines from passing into the drinking water.

5. Consideration shall be given to ease of resin removal and replacement.

4.4.6.2 Use of alternative disinfectants.

Disinfectants that react less with disinfection byproduct precursors may be used as long as pathogen control is maintained and disinfection byproduct and precursor removal standards are met. When using alternative disinfectants, facilities must maintain a distribution system residual of free chlorine or chloramines. Possible health effects of the byproducts produced by alternative disinfectants must be taken into consideration. Written approval of the department shall be obtained before changing disinfectants. The alternative disinfectants listed below may be used.

a. Chlorine Dioxide. Chlorine dioxide shall not be used as a distribution system disinfectant.

b. Chloramines. Chloramines are generally not suitable as primary disinfectants but may be used to provide required distribution system residuals. The following shall be considered before using chloramines.

    1. Existing facilities wanting to install chloramine disinfection shall do a disinfectant profile through the treatment plant and develop an inactivation benchmark. The results of the profile shall be submitted to the department along with the written request to change disinfectants.
    2. Nitrites and nitrates are primary health contaminants and must be kept below the maximum contaminant levels. Therefore, sampling in the distribution system shall be done to find if nitrification is occurring.
    3. Heterotrophic bacteria studies should be done routinely to assure that biological growths are controlled throughout the distribution system. Any study should include sufficient sampling to identify all problem areas.
    4. To help control microbial growths, break point chlorination should be obtained before adding ammonia to the water and converting to chloramines.
    5. Chlorination facilities must be provided that will allow free chlorine residuals to be maintained throughout the distribution system.
    6. All systems must notify all of its customers before converting to chloramines. Special care must be taken notify dialysis clinics, doctors clinics, hospitals, nursing homes, and home dialysis patients.

c. Ozone. Analyses for bromate production should be done early in the design process. Biological mediation or other byproduct removal processes shall be included as a part of the ozone facility design.

4.5. Softening.

The softening process selected must be based upon the mineral quality of the raw water and the desired finished water quality in conjunction with requirements for disposal of residuals or brine waste, cost of plant, cost of chemicals and plant location. Applicability of the process chosen shall, be demonstrated.

4.5.1 Lime or lime-soda process.

Design standards for rapid mix, flocculation, and sedimentation are in subsection 4.2. Additional consideration must be given to the following process elements:

a. Hydraulics. When split treatment is used, the bypass line should be sized to carry total plant flow, and an accurate means of measuring and splitting the flow must be provided;
b. Aeration. Determinations should be made for the carbon dioxide content of the raw water. When concentrations exceed 10 milligrams per liter, the economics of removal by aeration as opposed to removal with lime should be considered if it has been determined that dissolved oxygen in the finished water will not cause corrosion problems in the distribution system. When split treatment is utilized, the split should be prior to aeration, and the re-blending prior to filtration;
c. Chemical feed point. Lime should be fed directly into the rapid mix basin;
d. Rapid mix. Rapid mix basins must provide 30 seconds detention time with adequate velocity gradients to keep the lime particles dispersed;
e. Stabilization. Equipment for stabilization of water softened by the lime or lime-soda process is required;
f. Residuals collection and disposal.
    1. Mechanical residuals removal equipment shall be provided in the sedimentation basin; and
    2. Provisions must be included for proper disposal of softening residuals in accordance with regulations in 10 CSR 20;
g. Disinfection. The use of excess lime is no substitute for disinfection; and
h. Plant start-up. The plant processes must be manually started following shutdown, unless approved by the department where automatic monitoring controls are provided.

4.5.2. Cation exchange process.

a. Alternative methods of hardness reduction should be investigated when the sodium content and dissolved solids concentration are of concern.

b. Pre-treatment requirements. Iron, manganese, or a combination of the two, should not exceed 0.3 milligram per liter in the water as applied to the ion exchange resin. Pre-treatment is required when the content of iron, manganese, or a combination of the two, is one milligram per liter or more (see Section 4.6). Waters having five units or more turbidity should not be applied directly to the cation exchange softener.

c. Design. The units may be of pressure or gravity type, of either an upflow or downflow design. Automatic regeneration based on volume of water softened should be used unless manual regeneration is justified and is approved by the department. A manual override shall be provided on all automatic controls.

d. Exchange capacity. The design capacity for hardness removal should not exceed 20,000 grains per cubic foot when resin is regenerated with 0.3 pound of salt per kilograin of hardness removed.

e. Depth of resin. The depth of the exchange resin should not be less than three feet.

f. Flow rates. The rate of softening should not exceed seven gallons per minute per square foot of bed area and the backwash rate should be six to eight gallons per minute per square foot of bed area. Rate-of-flow controllers or the equivalent must be installed for the above purposes.

g. Freeboard**.** The freeboard will depend upon the specific gravity of the resin and the direction of water flow. Generally, the washwater collector should be 24-inches above the top of the resin on downflow units.

h. Underdrains and supporting gravel. The bottoms, strainer systems and support for the exchange resin shall conform to criteria provided for rapid rate gravity filters.

i. Brine distribution. Facilities should be included for even distribution of the brine over the entire surface of both upflow and downflow units.

j. Cross connection control. Backwash, rinse, and air relief discharge pipes must be installed in such a manner as to prevent any possibility of back-flow.

k. Bypass. A bypass must be provided around softening units to produce a blended water of desirable hardness. Totalizing meters must be installed on the bypass line and on each softening unit. The bypass line must have a shut-off valve and should have an automatic proportioning or regulating device. In some installations, it may be necessary to treat the bypassed water to obtain acceptable levels of iron and/or manganese in the finished water.

l. Additional limitations. Silica gel resins should not be used for waters having a pH above 8.4 or containing less than 6 milligrams per liter silica and should not be used when iron is present. When the applied water contains a chlorine residual, the cation exchange resin shall be of a type that is not damaged by residual chlorine. Phenolic resin should not be used.

m. Sampling taps. Sampling taps must be provided for the collection of representative samples. The taps shall be located to provide for sampling of the softener influent, effluent and blended water. The sampling taps for the blended water shall be at least 20 feet downstream from the point of blending. Sampling taps should be provided on the brine tank discharge piping.

n. Brine and salt storage tanks.

   1. Salt dissolving or brine tanks and wet salt storage tanks must be covered and must be corrosion-resistant.
   2. The make-up water inlet must be protected from backflow. Water for filling the tank should be distributed over the entire surface by pipes above the maximum brine level in the tank. The tanks should be provided with an automatic declining level control system on the make-up water line.
   3. Wet salt storage basins must be equipped with manholes or hatchways for access and for direct dumping of salt from truck or railcar. Openings must be provided with raised curbs and watertight covers having overlapping edges similar to those required for finished water reservoirs.
   4. Overflow, where provided, must be protected with a corrosion resistant screen and must terminate with either a turned-down bend having a proper free fall discharge or a self-closing flap valve.
   5. Two wet salt storage tanks or compartments designed to operate independently should be provided.
   6. The salt shall be supported on graduated layers of gravel placed over a brine collection system.
   7. Alternative designs which are conducive to frequent cleaning of the wet salt storage tank may be considered.

o. Salt and brine storage capacity. Total salt storage should have sufficient capacity to store in excess of 1½ carloads or truckloads of salt, and provide for at least 30 days of operation.

p. Brine pump or eductor. An eductor may be used to transfer brine from the brine tank to the softeners. If a pump is used, a brine measuring tank or means of metering should be provided to obtain proper dilution.

q. Stabilization. Stabilization for corrosion control shall be provided. An alkali feeder shall be provided except when exempted by the department.

r. Waste disposal. Disposal of brine waste must be in accordance with Clean Water Commission Regulations.

s. Construction materials. Pipes and contact materials must be resistant to the aggressiveness of salt. Plastic and red brass are acceptable piping materials. Steel and concrete must be coated with a non-leaching protective coating which is compatible with salt and brine.

t. Housing. Bagged salt and dry bulk salt storage shall be enclosed and separated from other operating areas in order to prevent damage to equipment.

4.6. Aeration.

Aeration may be used to help remove offensive tastes and odors due to dissolved gases from decomposing organic matter, or to reduce or remove objectionable amounts of carbon dioxide, hydrogen sulfide, etc., and to introduce oxygen to assist in iron and/or manganese removal. The design criteria in this section 4.6. is not intended for facilities to remove organics.

4.6.1 Forced or induced draft aeration.

Forced or induced draft aeration devices shall:

a. Include a blower with a weatherproof motor in a tight housing and screened enclosure;
b. Insure adequate counter current of air through the enclosed aerator column;
c. Exhaust air directly to the outside atmosphere;
d. Include a down-turned and 18-mesh screened air outlet and inlet;
e. Be designed such that air introduced in the column shall be as free from obnoxious fumes, dust, and dirt as possible;
f. Be designed such that one side or a portion of one side may be opened for inspection and maintenance of the interior of the aerator, and located so that all aspects of the aerator are easily accessible for maintenance;
g. Provide loading at a rate of one to five gallons per minute for each square foot of total tray area;
h. Insure that the water outlet is adequately sealed to prevent unwarranted loss of air;
i. Discharge through a series of five or more trays with separation of trays not less than six inches;
j. Provide distribution of water uniformly over the top tray;
k. Be resistant to the aggressiveness of the water and dissolved gases;
l. Provide for bypassing the treatment process with aerated water to facilitate disposal of iron residue during cleaning;
m. Not be located inside a building; and
n. Be constructed of stainless steel or aluminum.

4.6.2 Pressure aeration.

Pressure aeration may be used for oxidation purposes only if pilot plant study indicates the method is applicable. It is not acceptable for removal of dissolved gases. Filters following pressure aeration must have adequate exhaust devices for release of air. Pressure aeration devices shall be designed to:

a. Give thorough mixing of compressed air with water being treated;
b. Provide screened and filtered air, free of obnoxious fumes, dust, dirt, and other contaminants;
c. Have the necessary delivery capacity of air at 5 psi to 10 psi pressure, depending upon depth of water in the basin;
d. Give a detention period of 5 to 15 minutes based on design flow; and
e. Provide from 0.005 cubic foot to 0.2 cubic foot per gallon of water aerated.

4.6.3. Spraying.

a. Distribute water through spray nozzles with a pressure of approximately ten psi at the throat;
b. The area covered by the spray from each nozzle from about 10 to 200 square feet;
c. The output per nozzle from 40 to 175 gallons per minute, depending upon the type of nozzle; and
d. Protection from loss of spray water by wind carriage by enclosure with louvers sloped to the inside at an angle of approximately 45 degrees.

4.6.3 Other methods of aeration.

Other methods of aeration may be used if applicable to the treatment needs, subject to the approval of the department.

4.6.4 Protection of aerators.

All aerators except those discharging to lime softening or clarification plants shall be protected from contamination from birds, insects, and windborne debris.

4.6.5 Disinfection.

Groundwater supplies exposed to the atmosphere by aeration must receive chlorination as the minimum additional treatment.

4.6.6 Bypass.

A bypass shall be provided for all aeration units.

4.6.7 Corrosion control.

The aggressiveness of the water after aeration should be determined and corrected by additional treatment, if necessary.

4.7. Iron and Manganese Control

Iron and manganese control, as used in this section, refers solely to treatment processes designed specifically for this purpose. The treatment process used will depend upon the character of the raw water. The selection of one or more treatment process must meet specific local conditions as determined by engineering investigations, including chemical analysis of representative samples of water to be treated, and receive the approval of the department. It may be necessary to operate a pilot plant in order to gather all information pertinent to the design. Allowances must be made for deterioration of groundwater quality, over time, and for variations in ground water quality at different locations. Testing equipment and sampling taps shall be provided as specified in sections 2.8 and 2.10**.**

4.7.1. Removal by oxidation, detention and filtration.

a. Oxidation. Oxidation may be by aeration, as indicated in Section 4.6 or by chemical oxidation with chlorine, potassium permanganate, ozone, or chlorine dioxide.

b. Detention.

1. Reaction-A minimum detention time of two hours shall be provided following aeration for water containing iron or manganese to insure that the oxidation reactions are as complete as possible. This minimum detention time may be decreased only where indicated by a pilot plant study. The detention basin should be designed with sufficient baffling to prevent short-circuiting.
   - i. Provisions shall be made for adding chemicals for pH adjustment and enhancement of the oxidation process.
   - ii. Provisions shall be made for providing rapid mix of 30 seconds.
2. Sedimentation-A sedimentation basin in place of a detention basin shall be provided when treating water containing 4 mg/L or more iron and/or manganese, or where chemical coagulation is used to reduce the load on the filters. Provisions shall be made for adding chemicals for pH adjustment and enhancement of the oxidation process. Coagulant addition and rapid mixing should also be provided. Facilities for rapid mixing flocculation and sedimentation should be designed in accordance with section 4.1. Provisions for residuals removal shall be made. The detention basin shall be designed with sufficient baffling to prevent short-circuiting. The detention time in the sedimentation basin shall be based on the total concentration of iron and/or manganese in the water to be treated.
   - i. The following are the minimum detention times at different concentration ranges of iron and /or manganese exceeding 4 mg/L:
     1. 4mg/L to 9 mg/L - four hours detention time;
     2. 10mg/L to 20mg/L **-** six hours detention time; and

3. Above 20 mg/L – to be determined from pilot or full-scale demonstration plant study.

ii. The following provisions shall be included for combined reaction and sedimentation basins:

1. Provisions shall be made for adding chemicals for pH adjustment and enhancement of the oxidation process.
2. Provisions shall be made for adding a coagulant; and
3. Provisions shall be made for providing rapid mix of 30 seconds.

c. Removal by the lime-soda softening process. See paragraph 4.5.1.

d. Removal by manganese greensand or other propriety filter media.

i. This process consists of a continuous feed of potassium permanganate or other oxidizing chemical to the influent of a filter. Pilot studies must be done to obtain department approval.

ii. Provisions should be made to apply the permanganate as far ahead of the filter as practical and to a point immediately before the filter.

iii. Other oxidizing agents or processes such as chlorination or aeration may be used prior to the permanganate feed to reduce the cost of the chemical.

iv. Anthracite media cap of at least six inches shall be provid-ed over manganese greensand.

v. Normal filtration rate is three gallons per minute per square foot.

vi. Normal wash rate is eight to ten gallons per minute per square foot, or as recommended by the media manufacturer.

vii. Air washing should be provided.

viii. Sample taps shall be provided:

1. Prior to application of permanganate;
2. Immediately ahead of filtration; and
3. At the filter effluent.

ix. Sample taps should be provided:

1. At a point between the media layers; and
2. Halfway down the media when only one type media is utilized.

e. Removal by ion exchange. This process of iron and manganese removal should not be used for water containing more than 0.3 milligram per liter of iron, manganese or combination thereof. This process is not acceptable where either the raw water or wash water contains dissolved oxygen.

f. Sequestration by polyphosphates.

1. This process shall not be used when iron, manganese, or combina-tion thereof exceeds 1.0 milligram per liter. The total phosphate applied shall not exceed 10 milligrams per liter as orthophosphate.

Where phosphate treatment is used, provisions for disinfecting the water must be provided.

2. Feeding equipment shall conform to the requirements of Chapter 5 of this document.
3. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 milligrams per liter free chlorine residual.
4. Polyphosphates shall not be applied ahead of iron and manganese removal treatment. The point of application shall be prior to any aeration, oxidation, or disinfection if no iron or manganese removal treatment is provided.
5. Phosphate chemicals must be acceptable to the department.

g. Sequestration by sodium silicates.

1. Sodium silicate sequestration of iron and manganese is appropriate only to groundwater supplies prior to air contact. On-site pilot tests are required to determine the suitability of sodium silicate for the particular water and the minimum dose needed. Chlorination must precede the introduction of sodium silicate. Addition of sodium silicate must be within 15 seconds after the addition of chlorine.
2. Sodium Silicate addition is applicable to waters containing up to 2 mg/L of iron, manganese or combination thereof.
3. Equipment must be provided so that chlorine residuals can be maintained throughout the distribution system to prevent biological breakdown of the sequestered iron.
4. The amount of silicate added shall be limited to 20 mg/L as $Si0_2$, but the amount of added and naturally occurring silicate shall not exceed 60 mg/L as $Si0_2$.
5. Feeding equipment shall conform to the requirements of Chapter 5 of this document.
6. Sodium silicate shall not be applied ahead of iron or manganese removal treatment.
7. Quality of sodium silicate must be acceptable to the department.

4.8. Control of Organic Contamination.

Controlling organic contamination is an area of design that requires pilot studies and early consultation with the department. Where treatment is proposed, the best available technology shall be provided to reduce organic contaminants to the lowest practical levels.

4.8.1 Engineering Report.

Except for temporary, emergency treatment conditions, particular attention shall be given to developing an engineering report that, in addition to the normal determinations in section 1.1, includes the following:

a. Types of organic chemicals, sources, concentrations, frequency of occurrence if in surface water or estimated residence time within the aquifer and flow characteristics if in ground water, water pollution abatement schedule, etc.;
b. Possible treatment alternatives;
c. Results of bench, pilot, or full scale testing, demonstrating the effectiveness and cost of the treatment alternatives; and
d. A determination of quality and/or operational parameters which may serve as the best measurement of treatment performance, and a corresponding monitoring and process control program.

4.8.2 Control Alternatives.

In general, the design of control and treatment alternatives for organic contamination requires pilot or full scale testing. Collection of data pertinent to design is often complicated and lengthy. A permanent engineering solution for organic contamination may take significant time to develop. The following alternatives should be considered:

a. Alternative source development or purchase of water from nearby unaffected water systems may be a more expedient solution;
b. Modifications of existing treatment to enhance organic removal;
c. Air stripping for volatile organics. In designing the air stripping tower, consideration should be given to:
    1. Materials for tower, packing, and piping that are acceptable for use in contact with potable water;
    2. Providing a moisture barrier (de-mister);
    3. Metering the water flow to the tower;
    4. Metering the air flow to the tower;
    5. Providing influent and effluent sampling taps;
    6. Disinfecting the water passing through the tower;
    7. Designing the tower and air to water ratio to reduce the critical contaminants to the lowest practical level;
    8. The air discharge meeting the air quality standards of the Missouri Air Conservation Commission;
    9. Provision for easy inspection, maintenance, and cleaning of the packing materials. Iron and manganese precipitation, carbonate deposition, and biological fouling are potential problems;
    10. Chemical stability of the finished water; and
    11. Acceptable supply during periods of maintenance and operation interruptions; and
d. Adsorption by granular activated carbon. Consideration should be given to:
    1. Determining the filter isotherm for the particular contaminant to be removed, and the minimum contact time with the carbon bed that is necessary for removing the contaminant;
    2. Using contact units rather than replacing portions of existing filter media;

3. Series and parallel flow piping configurations to minimize the effect of breakthrough without reliance on continuous monitoring;
4. Providing at least two units. Where only two units are provided, each shall be capable of meeting the plant design capacity (normally the projected maximum daily demand) at the approved rate. Where more than two units are provided, the contactors shall be capable of meeting the design capacity at the approved rate with one (largest) unit out of service;
5. Using virgin carbon. Although reactivated carbon may present an economic advantage at large water treatment plants, such an alternative may be pursued only with the preliminary endorsement of the department. If regenerated carbon is accepted, only carbon previously used for potable water treatment can be used for this purpose. Transportation and regeneration facilities must not have been used for carbon put to any other use; and
6. Acceptable means of spent carbon disposal, pursuant to hazardous waste management regulations in 10 CSR 25.

4.9. Stabilization.

Water that is unstable due either to natural causes or to subsequent treatment should be stabilized. Chemicals can be fed to provide a stable to slightly depositing water or to mitigate the solubility of targeted parameters.

4.9.1. Carbon dioxide addition.

Carbon dioxide is generally fed at plants that lime soften to stop the softening process and prevent excess deposition of calcium carbonate onto filters and in the water distribution system. Carbon dioxide storage and feeding facilities shall meet the requirements of Chapter 5 of this document.

4.9.2. Acid addition.

a. Feed equipment shall conform to Chapter 5 of this document.
b. Adequate precautions shall be taken for operator safety, such as the provision of personal protective equipment, transfer pumps and not adding water to concentrated acid.
c. If bulk storage is used, containment walls that will adequately hold the acid must be provided.

4.9.3. Phosphates.

a. The feeding of phosphates may be applicable for sequestering calcium in lime-softened water, corrosion control, and in conjunction with alkali feed following ion exchange softening. However, feeding phosphates is not acceptable as a substitute for proper operation and maintenance of the existing coagulation, filtration or recarbonation processes.

b. Feed equipment shall conform to Chapter 5 of this document.
c. Phosphate quality must be acceptable to the department.
d. Stock phosphate solution must be kept covered and disinfected by carrying approximately 10 milligrams per liter free chlorine residual.
e. Phosphates can act as a nutrient for biological growth in water distribution systems. Therefore, disinfection equipment shall be provided that is sufficient to maintain disinfectant residuals throughout the distribution system at levels necessary to control biological growths. Heterotrophic bacteria studies should be done routinely to assure that biological growths are controlled through out the distribution system.

4.9.4. Split Treatment.

Treatment plants designed to use "split treatment" should also contain facilities for further stabilization by other methods. A series of tests for iron and manganese shall be performed on all of the water sources before considering split treatment. Iron and manganese tests shall be done upon startup and throughout the pumping cycle of each source to find out if surges of high concentrations occur. Plants that soften surface water shall not blend water for stabilization. Because of deposition, all blending for stabilization shall be done before filtration and bench tests shall be done to determine if blending alone will sufficiently stabilize the water.

4.9.5. Alkali Feed.

Aggressive water created by ion exchange softening shall be neutralized by an alkali feed that does not contain sodium. Alkali feeding facilities shall be provided for all ion exchange water softening plants except when exempted by the department. Adequate rapid mixing of the alkali with the water flow shall be provided. Turbidity monitoring may be necessary to assure that the alkali feed does not make the water cloudy.

4.9.6. Carbon dioxide reduction by aeration.

The carbon dioxide content of aggressive water may be reduced by aeration. Tests shall be done and data submitted to assure that the type of aerator proposed will provide the carbon dioxide reductions desired.

4.9.7. Other treatment.

Other treatment for controlling corrosive water by the use of sodium silicate and sodium bicarbonate may be used with the written approval of the department. Any proprietary compound must receive the specific written approval of the department before use.

4.9.8. Water unstable due to biochemical action in distribution system.

Unstable water resulting from bacterial decomposition of organic matter biochemical action within tubercles, and reduction of sulfates to sulfides should be prevented by maintaining a free chlorine residual of 0.5 mg/L throughout the distribution system. This may be done by boosting chlorine residuals or by a program of routine water main flushing.

4.9.9. Control.

Laboratory equipment shall be provided for determining the effectiveness of stabilization treatment. The preferred method of determining stability is the calcium carbonate stability test using a continuous calcium carbonate contactor and pH, alkalinity, and calcium hardness analysis equipment.

4.10. Taste and Odor Control.

Provision shall be made for the control of taste and odor at all surface water treatment plants. Equipment for routine sampling and microscopic examination of the source water shall be available to the public water supply. Taste and odor removal chemicals shall be added sufficiently ahead of other treatment processes to ensure adequate contact time for an effective and economical use of the chemicals. Where severe taste and odor problems are encountered, in-plant or pilot plant studies, or both, are required.

4.10.1 Flexibility.

Plants treating water known to have taste and odor problems should have equipment that makes several control processes available so the operator will have flexibility in operation. At a minimum, equipment for feeding powdered activated carbon and potassium permanganate should be provided. In addition, plant design should provide for feeding these chemicals at multiple locations in the treatment process.

4.10.2. Chlorination.

Chlorination can be used for the removal of some objectionable odors. Adequate contact time must be provided to complete the chemical reactions involved. Excessive potential disinfection byproduct production through this process should be avoided by adequate bench-scale testing prior to design.

4.10.3. Chlorine dioxide.

Chlorine dioxide has been generally recognized as a treatment for tastes caused by industrial wastes, such as phenols. However, chlorine dioxide can be used in the treatment of any taste and odor that is treatable by an oxidizing compound.

Provisions shall be made for proper generating, feeding, storing and handling of all chemicals associated with chlorine dioxide.

4.10.4. Powdered activated carbon.

Powdered activated carbon should be added as early as possible in the treatment process to provide maximum contact time. Flexibility to allow the addition of carbon at several points is required. Activated carbon should not be applied near the point of chlorine application. Flash mixing shall be provided to assure an even dispersion of the carbon in the water. The required rate of feed of carbon in a water treatment plant depends upon the tastes and/or odors involved**.** Provision should be made for adding from 0.1 milligram per liter up to at least 50 milligrams per liter at the maximum design flow of the treatment facilities.

4.10.5. Granular activated carbon adsorption units.

See subparagraph 4.8.2.d.

4.10.6. Copper sulfate and other copper compounds.

Continuous or periodic treatment of water with copper compounds to kill algae or other growths shall be controlled to prevent copper concentrations more than 1.0 milligrams per liter as copper in the plant effluent or distribution system. Only compounds approved by the department for use with potable water may be used**.** Care shall be taken to assure an even distribution. Equipment for routine sampling and microscopic examination of the source water shall be provided at the water plant to assure that over treatment does not occur. Approved equipment to daily test for copper concentrations shall be provided.

4.10.7. Aeration.

Literature searches or pilot studies shall be done to assure that the particular taste and odor-causing compounds can be removed by aeration before submitting plans and specifications.

4.10.8. Potassium permanganate.

Application of potassium permanganate is recommended, providing the treatment shall be designed so that finished water manganese concentrations do not exceed the 0.05 mg/L secondary maximum contaminant level. Equipment to daily test for manganese concentrations shall be provided**.**

4.10.9. Ozone.

Ozonation can be used as a means of taste and odor control. Adequate contact time must be provided to complete the chemical reactions involved. Ozone is generally more desirable for treating water with high threshold odors. Analyses for bromate should be done early in the design process. Biological mediation or other byproduct removal processes shall be included as a part of the ozone facility design.

4.10.10. Other methods.

The decision to use any other methods of taste and odor control shall be made only after careful laboratory and/or pilot plant tests and after obtaining the approval of the department.

4.11. Waste Handling and Disposal

Provisions shall be made for proper disposal of water treatment plant sanitary and process wastes such as discharges from water closets, urinals and lavatories and laboratory wastes, filter backwash water, brines and clarification, softening, iron and manganese residuals. All waste discharges are governed by regulatory agency requirements and shall be handled or treated to meet the applicable requirements. Additional permits and approvals other than those issued by the Missouri Public Drinking Water Program may be required. It is the responsibility of the water system officials or their representatives to submit all required applications, submittals, and permit fees to the appropriate agencies and to obtain all necessary permits.

All wastewater discharges shall meet the general water quality criteria in 10 CSR 20-7.031(3) and any additional criteria on the specific type of wastewater discharged. Treatment plant process residuals can be handled as a solid waste or through the wastewater permit process. If handled as a solid waste, residuals shall be hauled to a permitted sanitary landfill for disposal. Permanent residual storage makes the storage facilities a solid waste disposal site requiring the appropriate studies and permits. If handled through the wastewater permit process, residuals are land applied for agronomic purposes.

If the process residuals are to be land applied, those chemical characteristics that will affect its land application must be discussed as a part of the engineering report submitted to the department. Estimates of the amount of land required for disposal and of the years that the land can be used must be included. Process waste handling facilities shall be designed to be compatible with the drinking water treatment facilities and not adversely affect drinking water treatment. The process waste handling facilities must be designed to be compatible with the resources and capabilities of the specific system and its operators. Methods and equipment for efficiently removing and disposing of process waste must be part of the handling facility design. If land application is to be done by a contractor information must be submitted on the arrangements with a contractor to remove and land apply the residuals. The method and information used in estimating the amount and type of process waste produced must be part of the engineering report submitted to the department. In locating waste disposal facilities due consideration shall be given to preventing potential contamination of water sources, treatment facilities, and raw and finished water piping.

4.11.1. Earthen Lagoons and Holding Basins.

All earthen lagoons and holding basins shall be designed and constructed to meet the requirements of 10 CSR 20-8.020(3) for design of small sewerage works for waste stabilization ponds and shall be provided with the following:

a. a location free from flooding or protected to a minimum one in ten year flood;
b. a means of diverting surface water so that it does not flow into the lagoons;
c. a minimum usable depth of five feet;
d. a minimum freeboard of two feet;
e. an adjustable decanting device;
f. an effluent sampling point; and
g. a method to prevent brush and weed growth on the interior slopes of the lagoon berms. If rip rap is used, it should have a minimum depth of 18-inches and extend from the toe of each berm to the top of the slope. The rip rap should be provided in at least two layers with the first 12-inches consisting of mixed rock 2-inches and smaller in diameter.

4.11.2. Sanitary waste.

a. Shall be discharged directly to a permitted sanitary sewer system, when feasible, or to an adequate on-site treatment facility approved by the department;
b. Shall not be discharged to a process waste lagoon or backwash water lagoon or to a residual holding basin or tank;
c. May be discharged to sewage holding tanks when site restrictions, geology, or soil type prevents using a wastewater lagoon or septic tank and tile field. Sewerage holding tanks must be routinely pumped out and the waste hauled to a permitted wastewater treatment facility for disposal. The name of the wastewater treatment facility where the waste will be hauled for disposal must be part of the submittal to the department. Holding tank location must provide for easy access by hauling equipment. Holding tanks must be equipped with the necessary devices to effectively access and remove the waste from the holding tank.
d. Laboratory sample taps that run continuously while the plant is in operation can be discharged to a backwash holding basin or residuals lagoon by means of drainage that is separate from the laboratory sink and plant sanitary sewerage piping system.

4.11.3. Brine waste.

Brine waste from ion exchange plants, demineralization plants, or other plants that produce brine waste may be discharged to:

a. Sanitary sewers with the approval of the local wastewater system authority; or
b. A flowing stream provided the stream flow is adequate to provide the necessary dilution.

4.11.4. Lime softening residuals

Lime softening residuals may be land applied at agronomic rates. Residuals from plants using lime to soften water varies in quantity and in chemical characteristics depending on the softening process and the chemical characteristics of the water being softened. These characteristics govern the amount of residual that can be applied to any specific piece of ground. The engineering report submitted to the department shall include a discussion of the expected residual characteristics. Methods of treatment and disposal are as follows:

a. Lagoons may be used to temporarily store residuals until they can be removed for final disposal. Storage lagoon(s):
    1. Must be designed to be cleaned periodically;
    2. Submittals shall include descriptions and specifications on residuals removal, handling, processing and disposal equipment or shall include information on the arrangements with a contractor to remove and land apply the residuals.
    3. Submittals shall include a copy of facility specific, standard, operating procedures for residual removal and disposal. The operating procedures shall include a discussion of the manpower necessary for proper operation of the facilities;
    4. Shall be designed to provide a total of at least six months of residual storage calculated on the basis of 0.7 acre per million gallons per day per 100 milligrams per liter of hardness removed based on a usable lagoon depth of at least five feet;
    5. Must have at least two but preferably more, storage cells in order to give flexibility in operation; and
    6. Shall be designed to produce a wastewater effluent that meets the Missouri Clean Water Commission effluent and water quality standards and that is satisfactory to the department.
b. Discharge of lime residuals to sanitary sewers should be avoided since it may cause both liquid and residual volume problems at the sewage treatment plant and sewer plugging problems. This method shall be used only when the sewerage system has adequate capacity and ability to handle the lime residuals.
c. Disposal at a permitted sanitary land fill can be done as either a solid or liquid if the landfill can and will accept such waste, in accordance with solid waste management regulations.
d. Mixing of lime residuals with waste activated sludge may be considered as a means of co-disposal. All necessary approvals from the local wastewater system operating authority shall be obtained. Pilot studies or trial runs to determine the impact of the lime residuals on the

wastewater treatment facilities are recommended.

e. Mechanical drying of residuals may be considered. Pilot studies on a particular plant waste are required.
f. Calcination of residuals may be considered. Pilot studies on and detailed analyses of a particular plant waste are required.
g. Lime residual drying beds shall be constructed according to 10 CSR 20-8.170(8) for sludge drying beds

4.11.5. Clarification and Coagulation Residuals

An acceptable means of final residual disposal shall be provided as a part of the facility design and included in the engineering report. Clarification and coagulation residuals handling and disposal may consist of any of the following:

a. Mechanical concentration: A pilot plant study is required to design a mechanical residuals concentration installation. An engineering report explaining the findings and including data verifying the results of the pilot study shall be provided as a part of the Application for Construction Approval;
b. Freezing: Freezing changes the nature of clarification/coagulation residuals and allows it to be dried. Missouri weather does not allow natural freezing to be used as a reliable method and the department will not approve a proposal depending on natural freezing. A pilot study shall be done to design a residuals freezing installation. An engineering report explaining the findings and including data verifying the results of the pilot study shall be provided as a part of the Application for Construction Approval;
c. Acid treatment: Acid treatment of residuals for alum recovery has been done in some large water systems. Because acid dissolution is non-selective and will release natural organic matter, iron, heavy metals, and other contaminants present in the residuals, bench top or pilot studies must be done and the product produced analyzed to determine if undesirable chemicals will be produced. An engineering report explaining the findings and including results of all analyses must be submitted as a part of the Application for Construction Approval. These contaminants must be removed before the recovered alum can be used in drinking water treatment;
d. Discharge to sanitary sewer: Clarification/coagulant residuals may be discharged directly to a sanitary sewer if the wastewater treatment facilities are designed to remove and process the residuals. Because the residuals are not biodegradable and will settle and interfere with their operation, the department will not approve discharging residuals to systems using wastewater stabilization ponds or to wastewater plants using mechanical treatment unless they have facilities to remove the residuals before the biological treatment processes. The following shall be done to obtain an approval to discharge process residuals to a sanitary sewer system:

1. Obtain a letter of approval from the owner or operating authority of the sewerage system and submit a copy to the department;
2. Submit an engineering report explaining the impact of the residuals on the wastewater treatment facility and its sludge drying and handling facilities;
3. Submit evidence that the wastewater collection system, the wastewater treatment facilities and its sludge handling facilities are capable of handling the additional hydraulic and solids loading;
4. Because clarification / coagulant residuals may reduce the ability to dry bio-solids, pilot studies should be done to determine the ability of the wastewater facilities to handle the combined sludge; and
5. A holding basin for controlled discharge may be required; and

e. Lagoons: Lagoons may be used as a method of temporarily storing clarification/coagulant residuals.
1. Lagoons shall be designed to produce an effluent that meets the Missouri Clean Water Commission effluent and water quality standards and that is satisfactory to the department.
2. Lagoon size shall be calculated using the total amount of chemicals used plus a factor for turbidity. Unless justification is submitted for using another method clarification/coagulant sludge volume shall be calculated using the following formula:

   S lb/mg = 8.34 lb/gal X ((D mg/L ÷ 4) + Turbidity NTU + PAC mg/L)

   S lb/mg = Residual solids in pounds per million gallons of raw water pumped
   D mg/L = Coagulant dosages in milligrams per liter
   Turbidity NTU = average raw water turbidity
   PAC mg/L = powdered activated carbon dosage in milligrams per liter.

   To get the total volume of residuals, this product must be divided by the percent solids of the residuals. Total lagoon capacity shall provide at least six months of residual storage. When the residual lagoons are used for both residuals storage and filter backwash handling, the total capacity shall provide at least 12 months of storage.

3. Lagoons must have at least two, but preferably more, storage cells in order to give flexibility in operation.

4.11.6. Iron and Manganese Residuals and Wastewater.

Iron and manganese waste are regulated under the Missouri Clean Water Commission regulations by effluent limits set on iron and manganese concentrations. Waste filter wash water and settling basin residuals from iron and manganese removal plants may be processed and disposed of as follows:

a. Sand drying filters may be used to process waste filter wash water and settling basin residuals from treatment units that have automatic residual removal facilities. Sand filters shall have the following features:
    1. Total filter area, regardless of the volume of water to be handled, should be no less than 100 square feet. Unless the filter is small enough to be cleaned and returned to service in one day, two or more cells are required;
    2. Filters shall have sufficient capacity to contain, above the level of the sand, the entire volume of wash water produced by washing of all the production filters in the plant;
    3. Sufficient filter surface area should be provided so that, during any one filtration cycle, no more than two feet of backwash water will accumulate over the sand surface;
    4. The filter shall not be subject to flooding by surface runoff or flood waters. Finished grade elevation shall be designed to facilitate maintenance, cleaning and removal of surface sand as required;
    5. The filter media shall consist of a minimum of twelve inches of sand, three to four inches of supporting small gravel or torpedo sand and nine inches of gravel in graded layers. All sand and gravel shall be washed to remove fines;
    6. Unless the design engineer submits information justifying different sand sizes, filter sand shall have an effective size of 0.3 to 0.5 mm and a uniformity coefficient not to exceed 3.5;
    7. Each filter shall be provided with an adequate under drain system to permit satisfactory discharge of filtrate;
    8. Provision shall be made for the sampling of each filter effluent;
    9. Overflow devices from the filters shall not be permitted;
    10. Where freezing is a problem provisions should be made for covering the filters during winter months;
    11. Filters shall not have a common wall with a compartment storing finished water but shall be separate structures. Filter piping shall not create an unprotected cross-connection; and
    12. The provisions for the final disposal of the residuals shall be provided in the submittals to the department and the equipment or contractor arrangements necessary to remove and haul the sludge shall be specified.

b. Lagoons may be used to temporarily store residuals until they can be removed for final disposal. Lagoons shall have the following features:
    1. Be designed with a volume 10 times the total quantity of wash water discharged during any 24-hour period;
    2. A minimum usable depth of five feet;
    3. Length four times width and the width at least three times the depth, as measured at the operating water level;
    4. Outlet to be at the end opposite the inlet;
    5. Velocity to be dissipated at the inlet end; and

6. The provisions for the final disposal of the residuals shall be provided in the submittals to the department and the methods and equipment necessary to remove and haul the residuals shall be specified.

c. Discharge to community sanitary sewer
Iron and manganese residuals and wastewater can be discharged to a permitted community sanitary sewer. If the wastewater treatment facilities are designed to remove and process the residuals. Because the residuals are not biodegradable and will settle and interfere with their operation, the department will not approve discharging residuals to systems using wastewater stabilization ponds or to wastewater plants using mechanical treatment unless they have facilities to remove the residuals before the biological treatment processes. The following must be done to obtain an approval to discharge process residuals to a sanitary sewer system:
   1. Obtain a letter of approval from the owner or operating authority of the sewerage system and submit a copy to the department;
   2. Submit an engineering report explaining the impact of the residuals on the wastewater treatment facility and its sludge drying and handling facilities;
   3. Submit evidence that the wastewater collection system, the wastewater treatment facilities and the sludge handling facilities are capable of handling the additional hydraulic and solids loading; and
   4. A holding basin for controlled discharge may be required**.**

d. Recycling Iron and manganese wastewater
Recycling of supernatant or filtrate from iron and manganese waste treatment facilities to the head of an iron removal plant shall not be allowed.

4.11.7. Filter Backwash Water

a. May be discharged directly to a sanitary sewer under the following conditions.
   1. Approval from the owner or operating authority of the sewerage system must be obtained and proof of the approval must be submitted.
   2. The wastewater collection system and the wastewater treatment facilities must be capable of handling the hydraulic loading and evidence must be submitted to assure this.
   3. A holding basin for controlled discharge may be required.

b. Discharge to the waters of the state**.**
The waste wash water shall be treated to remove solids and chlorine residuals. Solids may be removed by gravity using a holding basin or lagoon. If sufficient holding time is provided, holding the wash water in a lagoon may allow the chlorine residual to be used up with no further treatment. Otherwise facilities must be provided to remove the chlorine residuals. Holding basins or lagoons shall have the following:

1. discharge structures that have sluice gates or valves to easily control the discharge;
2. a design that allows a dechlorinating chemical to be fed;
3. a minimum volume of three times the total quantity of wash water expected to be discharged during any 24-hour period;
4. a minimum water depth of three feet;
5. a length four times width and the width a least three times the depth as measured at the operating water level;
6. an outlet at the end opposite the inlet; and
7. Velocity to be dissipated at the inlet end.

c. Recycling waste filter wash water and filter to waste water to the head of the treatment plant may be considered. Plants treating surface water or groundwater under the influence of surface water should not recycle waste filter wash water.
   1. Holding basins or lagoons shall be sized to ensure that cleaning of other filters will not be delayed because of a full holding basin or lagoon. Unless the engineer can justify the use of other criteria, a holding basin or lagoon shall have a volume ten times the total quantity of wash water and filter to waste water required to clean one filter. Unless the engineer can justify the use of other criteria, a filter backwash shall be calculated at 20 gallons per minute per square foot for 15-minutes and filter to waste shall be calculated at 3 gallons per minute per square foot for 60-minutes.
   2. The holding basin or lagoon shall not receive discharges from sanitary facilities (water closets, urinals, lavatories, floor drains, sinks, etc.)
   3. Rate of recycling shall not exceed 10 percent of the raw water flow entering the plant regardless of the designed plant capacity.
   4. To determine the rate of flow, a meter shall be provided in the recycle piping. The meter shall have a remote readout located in the plant operations area that reads rate of flow in gallons per minute.
   5. To control rate of flow, a throttling valve or similar device shall be provided in the recycle piping.
   6. Filter backwash shall not be recycled when it contains excessive algae, iron, manganese or other contaminants; when finished water taste and odor or colored water problems are encountered or when it may cause disinfection byproduct levels in the distribution system to exceed allowable levels.

4.11.8. Wastes from Plants using Missouri or Mississippi River Water

The Missouri Clean Water Commission regulation 10 CSR 20-7.015(2) states that the suspended solids that are present in the water and are removed during treatment and any additional suspended solids resulting from the treatment of the water may be discharged to the Missouri River or the Mississippi River if the raw water source is:

a. Missouri River or Mississippi River waters.
b. Alluvial wells along the banks of the Missouri River or Mississippi River.

Chapter 5 -- Chemical Application

5.0 General.

No chemicals shall be applied to treat drinking water unless specifically permitted by the department. All chemicals used to treat drinking water shall be certified for drinking water use in accordance with ANSI/NSF Standard 60/61.

5.0.1. Plans and specifications.

Plans and specifications shall be submitted for review and approval, as provided for in Chapter 5 of this document. Because specifications for chemical feeding equipment are generally performance specifications that give feed ranges and generic descriptions, detailed manufacturers' information on the equipment actually installed must be provided to obtain the required Final Construction Approval from the department. Plans and specifications shall include:

a. Descriptions of feed equipment, including maximum and minimum feed ranges;
b. Location of feeders, piping layout and points of application;
c. Storage and handling facilities;
d. Specific chemicals to be used;
e. Operating and control procedures including proposed application rates and the results of chemical analyses, historic dosages, and the basis for choosing the proposed application rates, provided in the engineering report or as an appendix to the specifications; and
f. Description of testing equipment.

5.0.2. Chemical application.

Chemicals shall be applied to the water at such points and by such means to:

1. Ensure maximum efficiency of treatment;
2. Ensure maximum safety to consumer;
3. Provide maximum safety to plant personnel;
4. Ensure satisfactory mixing of the chemicals with the water;
5. Provide maximum flexibility of operation through various points of application, when appropriate;
6. Prevent backflow or backsiphonage between multiple points of feed through common manifolds;
7. Prevent any spillage of chemical into the mixing basin or settling basin. When chemical storage or feeders are located on top of the mixing and/or settling basin, a 4-inch to 6-inch curb shall be constructed around all the basin openings. Chemical feed or storage facilities shall not be located on top of pumping wells, transfer wells or clearwells unless specifically approved by the department; and
8. Minimize interference and undesirable reactions between chemicals.

5.0.3. General equipment design.

General equipment design shall be such that:

a. Feeders will be able to supply, at all times, the necessary amounts of chemicals at an accurate rate throughout the range of feed;
b. Chemical-contact materials and surfaces are resistant to the aggressiveness of the chemical solution;
c. Corrosive chemicals are introduced in such a manner as to minimize potential for corrosion and damage to water piping, treatment basins, and the water treatment facilities**;**
d. Chemicals that are incompatible are not fed, stored, or handled together;
e. All chemicals are conducted from the feeder to the point of application in separate conduits;
f. Chemical feeders are as near as practical to the feed point;
g. Chemical feeders and pumps operate at no lower than 20 percent of the feed range;
h. Chemicals are fed by gravity where practical; and
i. Adequate space is provided around each chemical feeder to safely load, operate, clean, and maintain each feeder.

5.1. FACILITY DESIGN.

5.1.1. Number of feeders.

a. Where chemical feed is necessary for the production of safe drinking water, such as chlorination, coagulation, or other essential processes:
    1. A minimum of two feeders shall be provided or a standby unit or a combination of units of sufficient capacity shall be available to replace the largest unit during shut-downs; and
    2. Where a booster pump or a transfer pump is required, duplicate equipment shall be provided and, when necessary, standby power.
b. A separate feeder shall be used for each chemical applied and should be used for each application point. Only one solution pump should draw from a solution tank, day tank, barrel, or carboy.
c. Spare parts shall be available for all feeders to replace parts that are subject to wear and damage.

5.1.2. Control.

a. Feeders may be manually or automatically controlled. Automatic controls shall be designed to allow override by manual controls and to allow adjustment of each control parameter.
b. When automatic controls are used, they shall include devices that prevent feeders from operating unless water is being produced**.**
c. When automatic controls are used, they shall include devices so that chemical feed rates shall be proportional to flow.

d. A means to measure all appropriate water flows must be provided in order to determine chemical feed rates.

e. Provision shall be made for measuring the volume or weight of chemicals used.

f. Weighing scales:

1. Shall be provided for weighing all active gas cylinders at all plants utilizing chlorine gas, carbon dioxide, or ammonia gas. Scales for weighing all gas cylinders smaller than one ton in size shall be low profile for ease in manually loading cylinders onto the scales. Otherwise, electric hoists, hoist tracks, and properly sized cylinder clamps shall be provided;
2. May be required for fluoride solution feed;
3. Shall be provided for each active chemical solution day tank;
4. Shall be provided for each solution or emulsion fed from carboys or barrels;
5. Shall be provided to weigh chemicals when making batches of chemical feed solutions**;**
6. Should be provided for volumetric dry chemical feeders;
7. Should be accurate to measure increments of 0.5 per cent of load; and
8. Totaling gas meters shall be provided to measure all gas chemicals fed from rail cars or bulk storage containers.

5.1.3. Dry chemical feeders.

Dry chemical feeders shall:

a. Measure chemicals volumetrically or gravimetrically;

b. Provide adequate solution water and agitation of the chemical in the solution pot;

c. Provide gravity feed from solution pots where possible;

d. Completely enclose chemicals to prevent emission of dust to the operating room;

e**.** Be located and designed to prevent lifting injuries when loading sacks of chemical into the feeder. The current OSHA or National Institute of Occupational Safety and Health (NIOSH) guidance for manual lifting should be followed;

f. Provide adequate space around each feeder to allow chemical pallets to be moved close to the feeder and minimize the distance that chemical bags or containers must be carried;

g. Have chemical hoppers sized to minimize loading frequencies to no more than once per eight-hour shift;

h. Not have bulk storage facilities that feed directly into the feed chamber but have a chemical hopper on the feeder that is large enough to minimize chemical fluidization;

i. Have vibrators and anti-bridging and caking equipment that is separate from those provided on the bulk storage facilities;

j. Have feeder shells and housings constructed of stainless steel, aluminum or a nonmetallic substance that fully enclose the chemical being fed to minimize chemical dust created by the feeding process;

k. Have solution tanks that are sized according to the amount of chemical to be fed. Undersized or oversized solution tanks shall be avoided; and

l. Have rate-of-flow meters on each solution-tank water line to control the amount of solution water going to dry feeder solution tanks.

5.1.4. Positive displacement solution pumps.

a. Positive displacement type solution feed pumps should be used to feed liquid chemicals, but should not be used to feed chemical slurries.

b. Bypass piping or other methods for accurately measuring the output of the chemical solution feeders shall be provided.

c. Graduated measuring chambers should be built into the feeder piping to allow the feeder output to be routinely checked.

5.1.5. Liquid chemical feeders - Siphon control.

Liquid chemical feeders shall be such that chemical solutions cannot be siphoned into the water supply. Liquid chemical feeders shall:

a. Assure discharge at a point of positive pressure;

b. Provide vacuum relief;

c. Provide a suitable air gap; or

d. Provide diaphragm anti-siphon devices that are spring-loaded in the closed position on the discharge side of each metering pump head or other suitable means or combinations as necessary. When metering pump anti-siphon devices are provided, they should be selected to provide the backpressure required by the pump manufacturer.

5.1.6. Backflow Prevention.

a. A reduced pressure principle backflow prevention assembly shall be provided on the service line supplying water to the water treatment plant according to the requirements of 10 CSR 60-11.010.

b. Backflow prevention shall be provided to ensure that the service water lines discharging to solution tanks shall be properly protected from backflow.
   1. Air gap separation shall be two times the pipe diameter of the water line serving any chemical solution tank.
   2. Atmospheric vacuum breakers conforming to the American Society of Sanitary Engineering (ASSE) standard #1001, shall be applied to water lines serving chemical solution tanks where no shut off or control valves are located downstream of the vacuum breaker.
   3. Pressure vacuum breakers conforming to ASSE standard #1020 shall be applied to water lines serving chemical solution tanks where shut off or control valves are located downstream of the vacuum breaker.

c. No direct connection shall exist between any sewer and a drain or overflow from a feeder, solution chamber or tank. All drains shall end at least six inches or two pipe diameters, whichever is greater, above the overflow rim of a receiving sump, conduit or waste receptacle.

5.1.7. Chemical feed equipment location.

Unless otherwise approved by the department chemical feed equipment shall:

a. Be located in a properly vented separate room(s) to reduce hazards and dust problems;
b. Be conveniently located near points of application to minimize length of feed lines;
c. Be readily accessible for servicing, repair and observing operation;
d. Be located so as to provide feeding by gravity;
e. Be located in a well-lighted area such that additional lighting is not required for normal operation and maintenance;
f. Be located in areas provided with the drains, sumps, finished water plumbing and the hose bibs and hoses necessary to fill solution tanks, clean up spills, and wash equipment;
g. Be located in areas that have floors and walls constructed of material that is suitable to the chemicals being stored and that is capable of being washed; and
h. Be located in areas with floor surfaces that are smooth and impervious, slip-resistant, and well drained with three inches per ten feet minimum slope.

5.1.8. Service water supply.

a. The quality of service water supplied to a treatment facility shall be compatible with the purposes for which it is used. Generally, only potable water should be used. Any proposal to use non-potable plant service water shall be submitted to and approved by the department before construction. When potable water is not used, the hose bibs and all water lines carrying non-potable water shall be clearly labeled. No cross-connection between potable and non-potable water lines is allowed.
b. The amount of solution water used to operate the feeders in a plant should be kept to the minimum necessary. This is especially important in small water treatment facilities. When specifying chemical feeders, the amount of service water required to operate the feeder must be considered.
c. Service water supply shall be:
    1. Ample in supply and adequate in pressure;
    2. Provided with a totaling water meter to determine the amount of water used by the plant;
    3. Properly treated for hardness, when necessary; and
    4. Properly protected against backflow.

5.1.9. Storage of chemicals

a. Space shall be provided for:

1. At least 30 days of chemical supply;
2. Convenient and efficient handling and rotating of chemicals;
3. Dry storage conditions; and
4. A minimum storage volume of 1 1/2 truckloads where bulk purchase is by truck load lots.

b. Chemical storage areas shall be provided with the drains, sumps, finished water plumbing and the hose bibs and hoses necessary to clean up spills and to wash equipment.
c. Chemical storage areas shall have floors and walls constructed of material that is suitable to the chemicals being stored and that is capable of being cleaned.
d. Chemical storage areas shall be well lighted and heated if liquid chemicals are stored.
e. Floor surfaces shall be smooth and impervious, slip-resistant and well drained with three inches per ten feet minimum slope.
f. Vents from feeders, storage facilities, and equipment exhaust shall discharge to the outside atmosphere above grade and remote from air intakes.
g. Storage tanks and pipelines for liquid chemicals shall be specific to the chemicals and not for alternates.
h. Chemicals shall be stored in covered or unopened shipping containers, unless the chemical is transferred into an approved covered storage unit.
i. Bulk liquid chemical-storage tanks must:
   1. Be constructed of material compatible with the chemical being stored;
   2. Have a calibrated gauge painted or mounted on the side if liquid level can be observed in a gauge tube or through translucent sidewalls of the tank. In opaque tanks, site tubes or a gauge rod extending above a reference point at the top of the tank, attached to a float, or other approved means may be used;
   3. Have an overflow that is located where noticeable and a receiving basin or drain capable of receiving accidental spills or overflows;
   4. Have an overflow line with a free fall discharge that is directed to minimize splashing and damage to the surrounding area;
   5. Have chemical fill lines located for ease in connecting to supply trucks and filling. Side-filling bulk liquid trucks are the most common so driveways and fill line locations should be designed for this type of truck. Lengthy fill lines should be avoided;
   6. Have chemical fill lines clearly labeled with the name of the chemical contained by the tank they serve. One set of labels should be located where the chemical supply trucks connect to the chemical fill lines;
   7. Be vented to the outside above grade and remote from air intakes with vents constructed of material compatible with the chemical being vented and screened to prevent insects from building nests that may plug the vent;
   8. Have vents and overflows sized to handle the chemical and air flow occurring during tank filling and discharging;

9. Have a valved drain, protected against backflow;
10. Be housed in a heated building or the tank and its chemical lines and transfer pumps otherwise protected from freezing; and
11. Be clearly labeled with the name of the chemical stored.

j. Full spill containment should be provided for all bulk storage tanks and shall be provided for some specific chemicals.

5.1.10. Solution tanks.

a. A means, which is consistent with the nature of the chemical solution, shall be provided in a solution tank to maintain a uniform strength of solution. Continuous agitation shall be provided to keep slurries in suspension.
b. Two solution tanks of adequate volume may be required for a chemical to assure continuity of supply in servicing a solution tank. When chemical solutions are mixed and fed in a batch process, solution tanks should be sized to minimize the filling frequency to no more than once per day.
c. Means shall be provided to measure the solution level in the tank.
d. Chemical solutions shall be kept covered. Large tanks with access openings shall have such openings curbed and fitted with tight overhanging covers.
e. Subsurface locations for solution tanks shall:
   1. Be free from sources of possible contamination; and
   2. Assure positive drainage for ground waters, accumulated water, chemical spills and overflows.
f. Overflow pipes, when provided, should:
   1. Be turned downward, with the end screened;
   2. Have a free fall discharge; and
   3. Be located where noticeable.
g. Acid storage tanks must be vented to the outside atmosphere, but not through vents in common with any other chemical.
h. Each tank should be provided with a valved drain, protected against backflow in accordance with paragraphs 5.2.5. and 6. of this document.
i. Solution tanks shall be located and protective curbing provided so that chemicals from equipment failure, spillage or accidental drainage shall not enter the water in conduits, treatment or storage basins.
j. Solution tanks shall be clearly labeled with the name of the chemical contained.

5.1.11. Day tanks.

a. Day tanks shall be provided where bulk storage of liquid chemical is provided.
b. Day tanks shall meet all the requirements of paragraph 5.2.10. of this document.
c. Day tanks should hold no more than a seven-day supply.
d. Day tanks shall be scale-mounted.

e. Hand pumps shall be provided for transfer of acids, caustic solutions or other hazardous chemicals from a carboy or drum into a day tank. For non-hazardous chemicals, a tip rack may be used to permit withdrawal into a bucket from a spigot. Where motor-driven transfer pumps are provided, a liquid level limit switch and an over-flow from the day tank must be provided. The over-flow from the day tank must drain by gravity back into the bulk storage tank or to a receiving basin or drain capable of receiving accidental spills or overflows.

f. A means that is consistent with the nature of the chemical solution shall be provided to maintain uniform strength of solution in a day tank. Continuous agitation shall be provided to maintain chemical slurries in suspension.

g. Tanks shall be properly labeled to designate the chemical contained.

h. Motor driven transfer pumps from bulk storage tanks shall be constructed and specified to handle the specific chemical being pumped.

i. Motor driven transfer pumps from bulk storage tanks shall be sized so they can fill the day tank while chemical is fed at the maximum output of the chemical feeder(s) pulling from the day tank. Under these conditions, the transfer pump(s) should be capable of filling the day tank in an hour.

j. Motor driven transfer pumps from bulk storage tanks shall be provided with discharge and suction valves located to allow the pump to be removed for maintenance without draining chemical from the lines to the bulk or day tank.

5.1.12. Chemical Feed lines.

a. All chemical feed lines should be as short as possible in length of run and should be straight.

b. Chemical solution lines:
   1. Should feed by gravity, where possible;
   2. Shall be of durable, corrosion resistant material that is compatible with the specific chemical being fed;
   3. Shall be easily accessible throughout the entire length;
   4 Shall be protected against freezing;
   5. Shall be adequately supported to prevent excessive movement and low areas where chemical will accumulate; and
   6. Shall be constructed to minimize plugging and to facilitate cleaning.

c. Chemical feed lines should slope upward from the chemical source to the feeder when conveying gases.

d. Chemical feed lines shall be designed consistent with scale-forming or solids-depositing properties of the water, chemical, solution, or mixture conveyed and shall be compatible with the chemical being fed.

e. Chemical feed lines should be color-coded, placarded, or otherwise clearly labeled with the name of the chemical contained. (See section 2.14. of this document).

f. Chemical feed lines shall be located so that plant operators do not have to routinely climb over them to get to other operating areas in the plant even if stiles or stairways are built over feed lines.

g. Chemical feed lines shall be located so that operators do not have to routinely walk under lines carrying strong corrosive, caustic or acid solutions.

5.1.13. Pumping of Chemicals.

When feeding of chemicals by gravity cannot be attained, pumping of chemicals to the different points of application may be considered. The chemical feed pumping system shall provide:

a. Standby pumping;
b. Spare chemical feed line for each chemical;
c. Minimum velocity of 4 feet per second through chemical feed lines;
d. For pigging chemical feed lines and baskets for catching pigs;
e. Water for flushing the chemical feed lines. The waterline must be protected from back-siphonage;
f. Discharge and suction valves located to allow each pump to be removed for maintenance or a means to safely drain the lines prior to disconnection for repairs;
g. Pumps constructed from material that is compatible with the specific chemical being pumped and that are easy to access, disassemble, and maintain;
h. Pumps that are located so that they are not tripping or fall hazards and so that they or their motors are not subject to damage by chemical spilled during routine loading and operation of solution tanks or feeders; and
i. Encasement conduits for underground feed lines for easy removal and maintenance.

5.1.14. Handling.

a. Carts, elevators, and other appropriate means shall be provided for lifting chemical containers to minimize excessive lifting by operators.
b. Provisions shall be made for disposing of empty bags, drums, or barrels by an approved procedure that will minimize exposure to dusts.
c. Provision shall be made for the proper transfer of dry chemicals from shipping containers to storage bins or hoppers, in such a way as to minimize dust. Control should be provided by use of:
    1. Vacuum pneumatic equipment or closed conveyor or elevator systems;
    2. Facilities for emptying shipping containers in special enclosures; or
    3. Exhaust fans and dust filters that put the hoppers or bins under negative pressure.
d. Provision shall be made for measuring quantities of chemicals used to prepare feed solutions.

5.2. Chemicals.

5.2.1 Shipping containers.

Chemical shipping containers shall be fully labeled to include chemical name, purity, and concentration and supplier names and addresses.

5.2.2 Assay.

Provisions may be required for assay of chemicals delivered.

5.3. Operator Safety.

5.3.1 Ventilation.

Special provisions shall be made for ventilation of chlorine, chlorine dioxide, anhydrous ammonia and ozone generation, and feed and storage rooms.

5.3.2. Respiratory protection equipment.

a. Respiratory protection equipment meeting the requirements of NIOSH shall be available for each chemical dust, vapor, or gas that may be encountered at a treatment plant. This respiratory protection equipment shall be stored at a convenient location, but not inside any room where the particular chemical is used or stored.
b. Self contained breathing apparatus units shall use compressed air, have at least a 30 minute capacity, have full face masks, and be compatible with units used by the fire department responsible for the plant.

5.4. Specific Chemicals.

Chemical storage handling and feeding facilities for the chemicals specified here shall meet all of the appropriate general requirements of this document and the chemical-specific requirements specified in this chapter.

5.4.1. Chlorine gas.

a. Chlorine gas feed and storage shall be enclosed and separated from other operating areas. The chlorine room or building shall be:
    1. Constructed of fire and corrosion resistant material;
    2. Provided with a shatter-resistant inspection window installed in an interior wall for chlorine rooms;
    3. Orientated so that the feeder settings and scale readings can be easily read from the inspection window and eliminate the need to frequently enter the room or building;
    4. Constructed in such a manner that all openings in a chlorine building or between the chlorine room and the remainder of the plant are sealed. These seals must be capable of withstanding the pressures expected from expanding chlorine gas. Areas sealed shall include, but not be limited to, electrical conduit, switches, lights and receptacles,

ducts, wall, and ceiling and floor joints. Floor drains are not recommended; however, where installed, they shall be plugged or sealed. All holes through the walls, ceiling and floor shall be sealed around where pipes conduits, wires, brackets, fixtures, etc., pass. All chlorine building or room doors shall be designed and fitted to contain chlorine gas leaks inside the room or building.

5. Provided with doors equipped with panic bars assuring ready means of exit and opening only to the building exterior;
6. Provided with doors that lock to prevent unauthorized access but do not need a key to exit the locked room using the panic bars**;**
7. Well lighted with lights that are sealed so that they will continue working during a chlorine leak;
8. Sized to allow the safe maneuvering of gas cylinders using hand trucks or electric hoists; and
9. If free-standing, located down grade from the water treatment plant.

b. Full and empty cylinders of chlorine gas shall be:
   1. Housed in the chlorine storage building or feed or storage room(s)
   2. Restrained in position to prevent upset or rolling,
   3. Stored separate from ammonia, ammonium hydroxide, paint thinner, solvent and petroleum product storage; and
   4. Stored in areas not in direct sunlight or exposed to excessive heat.

c. Where chlorine gas is used, the building or room shall be constructed to provide the following:
   1. Each room or building shall have a ventilating fan or fans with a capacity that provides one complete air change per minute when the room is occupied. The fans shall be constructed of chemical resistant materials and have chemical proof motors. Squirrel cage type fans located outside the chlorine room(s) may be approved if their fan housings and ducting are airtight and made of chlorine and corrosion resistant material;
   2. The ventilating fan(s) shall take suction near the floor as far as practical from the door and air inlet, with the point of discharge located remote from the entrance door to the chlorine room and so that exhausted chlorine gas will not enter any other parts of the water plant or other buildings**,** rooms or structures. Wall fans located in or beside the entrance doors to chlorine feed or storage room shall not be allowed;
   3. Air inlets shall be from the outside the building and be through louvers near the ceiling. These inlet louvers shall seal tightly. Motor operated louvers shall be provided with chlorine and corrosion resistant motor controls and electric connections;
   4. Separate switches for fans and lights shall be outside of the room and beside the entrance door and the interior inspection window. These switches shall be clearly labeled as to what they operate. A signal light indicating fan operation should be provided; and
   5. Vents from feeders and storage containers shall discharge to the

outside atmosphere, above grade and be screened to prevent insects from nesting in and plugging the vents.

d. Heating equipment for chlorinator rooms shall be capable of maintaining a minimum temperature of 60^{o}F and protected from excessive heat. Cylinders and gas lines should be maintained at the same temperature of the feed equipment. Heating or air conditioning equipment provided shall be separate from central heating and air conditioning systems to prevent chlorine gas from escaping. Central heating or cooling ducts shall not terminate in or pass through a chlorine room.

e. Pressure chlorine feed lines shall not carry chlorine gas beyond the chlorinator room. Chlorine gas feed systems that are under a vacuum from the gas cylinder valve out are preferred**.**

f. Sufficient chlorine gas manifolds, cylinder valves, piping and other equipment shall be provided to connect enough chlorine storage containers to a feeder or feeders so as to not exceed the dependable continuous discharge rate of any chlorine gas container. Circulating fans shall not be used to prevent frosting of containers or freezing of feed lines or to increase discharge rates. The normal dependable continuous discharge rate from a 150-lb or 100-lb chlorine gas cylinder is 1¾ pounds per hour at 70 °F and a 35 psi backpressure.

g. Chlorine gas leak detection and control.
    1. A bottle of ammonium hydroxide, 56 percent ammonia solution, shall be available for chlorine leak detection.
    2. Where ton or larger containers are used, at least one atmospheric chlorine gas detector shall be provided in each chlorine storage and feed room. Atmospheric chlorine-gas detectors shall be continuous leak-detection equipment and shall be provided with both an audible alarm and a warning light. Continuous leak-detection equipment should be provided for systems using 150-lb or smaller cylinders.
    3. Where ton containers are used, a leak repair kit approved by the Chlorine Institute shall be provided.
    4. Valves should be provided that will automatically shut off all active chlorine-gas cylinders during a leak.
        1. These valves shall be mounted on the chlorine-gas cylinder valves and shall be capable of rapidly shutting off a cylinder even during a power failure.
        2. The valves and all other parts of the automatic system shall be constructed of or encased in chlorine compatible and corrosion resistant material
        3. Operation of the valves shall be controlled by a signal from an atmospheric chlorine gas detector or control room.
        4. A manual shut-off switch shall be provided that also acts as a test switch to provide a full cycle test of the valve actuator.
        5. Audible alarms and warning lights shall be provided indicating when a gas leak and valve shut down has occurred.
        6. Running lights shall be provided to indicate whether a valve is

closed or open.

h. Chlorination equipment.
   1. Type. Solution-feed gas chlorinators or hypochlorite feeders of the positive displacement type must be provided for feeding the chlorine compounds, and ozonation equipment as specified for feeding ozone.
   2. Capacity. The chlorinator capacity shall be such that a free chlorine residual of at least 2 milligrams per liter can be maintained in the water after the required chlorine contact time even when maximum flow rate coincides with anticipated maximum chlorine demand. The equipment shall be of such design that it will operate accurately over the desired feeding range.
   3. Standby equipment. Where chlorination is required for protection of the supply, standby equipment of sufficient capacity shall be available to replace the largest unit. Spare parts shall be made available to replace parts subject to wear and breakage.
   4. Automatic switchover. Automatic switchover of chlorine cylinders should be provided, where necessary, to assure continuous disinfection.
   5. Automatic proportioning. Automatic proportioning chlorinators will be required where the rate of flow or chlorine demand is not reasonably constant.
   6. Eductor. Each eductor must be selected for the point of application with particular attention given to the quantity of chlorine to be added, the maximum injector water flow, the total discharge back pressure, the injector operating pressure, and the size of the chlorine solution line. Gauges for measuring water pressure and vacuum at the inlet and outlet of each eductor should be provided.
   7. Injector/diffuser. The chlorine solution injector/diffuser must be compatible with the point of application to provide a rapid and thorough mix with all the water being treated. The center of a pipeline is the preferred application point.
i. Chlorinator piping.
   1. Cross connection protection. The chlorinator water supply piping shall be designed to prevent contamination of the treated water supply by sources of questionable quality. At all facilities treating surface water, pre-and post-chlorination systems must be independent to prevent possible siphoning of partially treated water into the clearwell. The water supply to each eductor shall have a separate shut-off valve. No master shut-off valve will be allowed.
   2. Pipe material. The pipes carrying elemental liquid or dry gaseous chlorine under pressure must be Schedule 80 seamless steel tubing or other materials recommended by the Chlorine Institute (never use PVC). Rubber, PVC, polyethylene, or other materials recommended by the Chlorine Institute must be used for chlorine solution piping and fittings. Nylon products are not acceptable for any part of the chlorine solution piping system.

5.4.2. Acids.

a. Acids shall be kept in closed acid-resistant shipping containers or storage units.
b. Acids shall not be handled in open vessels, but shall be pumped in undiluted form from original containers through a suitable piping to the point of treatment or to a tightly sealed, vented and covered day tank.
c. To reduce the hazard to the water plant, acids shall not be diluted. Instead, the metering pumps specified shall permit the use of undiluted acid for installations of any size.

5.4.3. Chlorine Dioxide.

a. Sodium chlorite and sodium chlorate solutions and acids used to generate chlorine dioxide shall not be stored in a chlorine feed or storage room or in any area that may be affected by a chlorine gas leak or by vapors from chlorine compounds.
b. Federal and state rules set plant and distribution system monitoring requirements for systems feeding chlorine dioxide. Thus, the necessary approved analyses equipment, monitoring equipment, and laboratory facilities shall be provided to test for chlorine dioxide and chlorites.
c. Sodium Chlorite and Sodium Chlorate Storage.
    1. The department, before the preparation of final plans and specifications, shall approve proposals for the storage and use of sodium chlorite.
    2. Provision shall be made for proper storage and handling of sodium chlorite to eliminate any danger of fire or explosion associated with its powerful oxidizing nature.
    3. Sodium chlorite or chlorate solutions shall be stored by themselves in a cool, dry, fireproof, separate room. Preferably, they should be stored in an outside building detached from the water treatment facility.
    4. Sodium chlorite or chlorate solutions shall be stored away from organic materials because many materials will catch fire and burn violently when in contact with sodium chlorite or chlorate.
    5. Storage shall be away from combustibles and acids.
    6. The storage structures shall be constructed of noncombustible materials.
    7. If the storage structure must be located in an area where a fire may occur, water shall be available to keep the sodium chlorite area cool enough to prevent heat-induced explosive decomposition of the chlorite.
    8. The storage structure shall be provided with a separate, non-combustible, corrosion-resistant ventilation system to capture mist or fumes.
    9. Full spill containment shall be provided. Furthermore, storage facilities shall not be located over plant treatment basins, pumping

wells, transfer wells, or clearwells.

d. Sodium Chlorite and Sodium Chlorate Handling
   1. The design shall provide the drains, sumps, finished water plumbing, hose bibs and hoses necessary to clean up spills and to wash equipment.
   2. An emergency plan of operation should be developed for the clean up of any spillage.
   3. Storage drums must be thoroughly flushed before recycling or disposal.
   4. Protective safety equipment for the operators shall be provided that includes, but may not be limited to, chemical safety goggles, butyl rubber or neoprene gloves, self-contained breathing apparatus and waterproof outer clothing.

e. Sodium Chlorite and Sodium Chlorate Feeders.
   1. Positive displacement feeders shall be provided for feeding the acids and sodium chlorite and chlorate solutions.
   2. Methods for accurately metering or weighing the sodium chlorite and chlorate solutions shall be provided. Graduated measuring chambers should be built into the feeder piping to allow the feeder output to be routinely checked.
   3. Tubing for conveying sodium chlorite or chlorine dioxide solutions shall be Type 1 PVC, polyethylene or materials recommended by the manufacturer.
   4. Feed lines shall be installed in a manner to prevent formation of gas pockets and shall terminate at a point of positive pressure.
   5. Check valves shall be provided to prevent the backflow of chlorine into sodium chlorite or chlorate lines.
   6. Storage tanks inside buildings, day tanks and unsealed carboys or barrels shall be vented to the outside with a vent approved by the department.
   7. To reduce the hazard to the water plant operators, sodium chlorite and chlorate solutions and the required acids shall not be diluted. Instead, the metering pumps specified shall permit the use of undiluted solutions for installations of any size.

5.4.4. Chloramines.

a. Anhydrous ammonia.
   1. Anhydrous ammonia storage and handling facilities shall be designed to meet OSHA Standard 1910.111.
   2. With rising temperature, ammonia expands rapidly, increasing the internal pressure in vessels and pipes, etc. This shall be considered in the design and operation of ammonia systems
   3. Anhydrous ammonia feeding facilities shall be located in a separate enclosed room that meets all of the requirements of subparagraph 5.5.1.1. of this document for chlorine gas feeding facilities. However, only explosion-proof electric fixtures shall be used in the room.

4. Anhydrous ammonia contact with chlorine or fluorine can create explosive compounds. Therefore, feeding and storage facility design shall consider methods of preventing ammonia or chlorine leaks from coming into contact with either chemical. Furthermore, fluoride-feeding facilities shall not be located in ammonia feeding or storage rooms.

b. Ammonia Solutions.
   1. Storage.
      1. Ammonia solutions shall be kept in tightly closed containers stored in a separate cool, dry, ventilated room and kept from all forms of chlorine, strong acids, most common metals, strong oxidizing agents, aluminum, copper, brass, bronze, chlorite or chlorate solutions, and other incompatible chemicals.
      2. Ammonia solutions shall be protected from direct sunlight.
      3. The storage room shall be provided with a separate, corrosion-resistant ventilation system to capture mist or fumes and vent them to the outside.
      4. Ammonia solution containers may be hazardous when empty since they retain product residues. Therefore, all warnings and precautions listed for the product should be observed for empty containers.
   2. Ammonia Solution Handling.
      1. Ammonia solutions are very toxic to aquatic life and spills may not be drained into some sanitary sewer systems. Therefore, full spill containment shall be provided.
      2. Absorbent pads and the drains, sumps, finished water plumbing, hose bibs, and hoses necessary to clean up spills and to wash equipment shall be provided.
      3. An emergency plan of operation should be developed for the clean up of any spillage.
      4. Provide protective safety equipment for water plant personnel that includes but is not limited to chemical safety goggles, butyl rubber or neoprene gloves, self-contained breathing apparatus and water proof outer clothing.
      5. To reduce the hazard to the water plant personnel, ammonia solutions shall not be diluted. Instead, solution with the correct strength for the amount fed shall be purchased, or the metering pump specified shall permit the use of undiluted solution for water plants of any size.
   3. Ammonia Solution Feeders.
      1. Positive displacement feeders shall be provided for feeding the ammonia solutions.
      2. Methods for accurately metering or weighing the ammonia solutions shall be provided. Graduated measuring chambers should be built into the feeder piping to allow the feeder output to be routinely checked.

3. Tubing for conveying ammonia solutions shall be Type 1 PVC, polyethylene or materials recommended by the manufacturer.
4. Feed lines shall be installed in a manner to prevent formation of gas pockets and shall terminate at a point of positive pressure.
5. Storage tanks and unsealed carboys or barrels shall be vented to the outside with a vent approved by the department.

5.4.5. Carbon dioxide

a. Recarbonation basin design shall provide:
   1. A minimum detention time of twenty minutes,
   2. Two compartments, each with a depth of eight feet, as follows:
      1. A mixing compartment having a detention time of at least three minutes; and
      2. A reaction compartment.

b. If a carbon dioxide solution is added and rapid mixing is provided, total detention time and basin depths may be reduced. However, supporting data for the proposed reductions must be included as a part of the pre-design submittals.

c. Plants generating carbon dioxide from combustion shall have open top, recarbonation tanks in order to dissipate carbon monoxide and carbon dioxide. Special considerations shall be given to building ventilation when open recarbonation tanks are housed in a building.

d. Where liquid carbon dioxide is used, adequate precautions must be taken to prevent carbon dioxide from entering the plant from the feed lines or recarbonation process. Since liquid carbon dioxide is a cryogenic and a compressed gas, the recommendations of the Compressed Gas Association, Inc. shall be followed when specifying storage and feeding facilities.

e. Provisions shall be made for draining recarbonation basins and removing residuals.

5.4.6. Phosphates.

a. Stock phosphate solution must be kept covered and disinfected by carrying approximately ten milligrams per liter free chlorine residual.

b. Phosphates can act as a nutrient for biological growth in water distribution systems. Therefore, disinfection equipment shall be provided that is sufficient to maintain disinfectant residuals throughout the distribution system at levels necessary to control biological growths. Heterotrophic bacteria studies should be done routinely to ensure that biological growths are controlled through out the distribution system.

5.4.7. Powdered activated carbon.

a. Powdered activated carbon feed and storage facilities.
   1. Powdered activated carbon shall be handled as a potentially

combustible material.

2. Powdered activated carbon shall be stored in a building or compartment as nearly fireproof as possible.
3. A separate room shall be provided for carbon feed installations and other chemicals should not be stored in the same compartment.
4. Carbon feeder rooms shall be equipped with explosion-proof electrical outlets, lights and motors.
5. If possible, the feeder drive controls should be located outside the carbon room.
6. The carbon feed room should be large enough to house the carbon feeder and to store all of the powdered carbon present at the plan safely. Thus, the door to the carbon feed and storage room must be large enough to accommodate a loaded pallet of carbon.
7. Access to the carbon room should be from outside the plant to keep carbon from being tracked throughout the water plant.

b. Powdered activated carbon feeding.

1. Powdered activated carbon should be added as early as possible in the treatment process to provide maximum contact time.
2. Flexibility to allow the addition of carbon at several points is required.
3. Powdered activated carbon should not be applied near the point of chlorine application.
4. The effectiveness of powdered activated carbon depends upon the carbon particles physically contacting the chemicals to be adsorbed. Therefore, flash mixing shall be provided to ensure an even dispersion of the carbon in the water.
5. The carbon can be added as a pre-mixed slurry or by a dry-feed machine as long as the carbon is properly wetted. However, solution pipe plugging is a constant problem when pumping carbon slurries. Carbon feed design must consider ways to mediate this problem by using wetting cones and eductors, dual headed slurry pumps, etc.
6. Continuous agitation or suspension equipment is necessary to keep the carbon from depositing in the slurry storage tank.
7. Provision shall be made for adequate dust control by providing exhaust fans and dust filters.
8. Provision shall be made for adding from 0.1 milligram per liter to at least 50 milligrams per liter at the maximum design flow of the treatment facilities.

c. Powdered activated carbon handling.

1. Operators shall be provided with respiratory protection that meets OSHA regulation 29 CFR 1910.134 for coal dust. More information on the selection and use of respirators can be obtained from the latest issue of NIOSH Respirator Decision Logic.
2. Additional personal protective equipment to protect skin and eyes should be provided for dry feeder operations and shall be provided for operators that batch make carbon slurries.

5.4.8. Fluoridation

Commercial sodium fluoride, sodium fluorosilicate and fluorosilicic acid shall conform to the appropriate American Water Works Association (AWWA) standards (B-701, B-702, and B-703) to ensure that the drinking water will be safe and potable. The department must approve other fluoride compounds that may be available. The department must approve the proposed method of fluoride application before preparation of final plans and specifications.

a. Fluoride compound storage. Fluoride chemicals should be isolated from other chemicals to prevent contamination. Compounds shall be stored in covered or unopened shipping containers and should be stored inside a building. Adequate ventilation in storage area is necessary. Bags, fiber drums, and steel drums should be stored on pallets. Carboys, day tanks, or inside bulk storage tanks containing fluosilicic acid must be completely sealed and vented to the atmosphere at a point outside any building. Bulk storage tanks for fluorosilicic acid must be provided with secondary containment and shall not be located over plant treatment basins, pumping wells, transfer wells or clearwells. Unsealed storage units for hydrofluosilicic acid shall be vented to the atmosphere at a point outside any building.
b. Chemical feed equipment and methods. Fluoride feed equipment shall meet the following requirements:
    1. The fluoride feed system must be installed so that it cannot operate unless water is being produced (interlocked). For example, the metering pump must be wired electrically in series with the main well pump or the service pump. If a gravity flow situation exits, a flow switch shall be installed.
    2. When the fluoridation system is connected electrically to a well or service pump, it must be made physically impossible to plug the fluoride metering pump into any continuously active ("hot") electrical outlet. The pump shall be plugged only into the circuit containing the interlock protection.
    3. A secondary flow-based control device (e.g., a flow switch or a pressure switch) should be provided as back-up protection.
    4. The fluoride injection point should be located where all the water to be treated passes. However, fluoride should not be injected at sites where substantial losses of fluoride can occur. Fluoride compounds shall not be added before lime-soda softening or ion exchange softening.
    5. The fluoride injection point in a water line should be located in the lower one third of the pipe, and the end of the injection line should extend into the pipe approximately one-third of the diameter of the pipe.
    6. A corporation-stop valve should be used at the fluoride injection point when injecting fluoride under pressure. To protect water plant operators, a safety chain shall be installed in the assembly at the fluoride injection point if a corporation stop valve assembly is used.
    7. Two diaphragm-type antisiphon devices must be installed in the

fluoride feed line when a metering pump is used. These antisiphon devices should have a diaphragm that is spring-loaded in the closed position. One device should be located at the fluoride injection point and one device shall be located at the metering pump head on the discharge side. Metering pump antisiphon devices should be selected to provide the backpressure required by the pump manufacturer.

8. Operation of a fluoridation system without a functional antisiphon device can lead to an overfeed that exceeds 4 mg/L. Therefore, maintenance manuals, tools and repair parts must be provided to the system operators so that all antisiphon devices can be dismantled and visually inspected at least once a year. Schedules of repairs or replacements should be based on the manufacture's recommendations. Equipment for semiannual vacuum testing of all antisiphon devices should be provided.
9. Fluoride metering pumps should be located on a shelf not more than 4 feet (1.2 m) higher than the lowest normal level of liquid in the carboy, day tank, or solution container. A flooded suction line is not recommended in water fluoridation.
10. For greatest accuracy, metering pumps should be sized to feed fluoride near the midpoint of their range. Pumps should always operate between 30%-70% of capacity. Metering pumps that do not meet these size specifications should not be installed. Oversized metering pumps should not be used because serious overfeeds (i.e., an overfeed that exceeds 4 mg/L) can occur if they are set too high. Conversely, undersized metering pumps can cause erratic fluoride levels.
11. Priming switches on the metering pumps shall be spring-loaded to prevent pumps from being started erroneously with switches in the priming position.
12. Flow meter-paced systems should not be installed unless the rate of water flow past the point of fluoride injection varies by more than 20%.
13. A master meter on the water service line must be provided so that calculations can be made to confirm that the proper amounts of fluoride solution are being fed.
14. Fluoride solutions shall not be injected in a point of negative pressure.
15. The fluoride feed line(s) should be either color-coded, when practical, or clearly identified by some other means. Color-coding helps prevent possible errors when taking samples or performing maintenance. The pipes for all fluoride feed lines should be painted light blue with red bands. The word "fluoride" and the direction of the flow should be printed on the pipe or, for small piping, on the wall beside the pipe.
16. The dilution water pipe shall end at least two pipe diameters above the highest water level in the solution tank, or an adequate backflow prevention device must be provided. All hose connections within reach of the fluoride feed equipment should be provided with a hose-bib vacuum breaker.

17. Cross-connection controls must be provided that conforms to state regulations in 10 CSR 60-11.010.
18. Hose bibs and water supply piping to supply potable water for clean up of spills shall be provided in both the chemical feed and storage areas. The number of hose bibs and their location depend upon the size of the areas served.

c. Sodium Fluoride Saturator Systems. Sodium fluoride systems are not recommended but may be considered on a case-by-case basis with the department's written approval**.**

d. Fluorosilicic Acid Systems.
    1. To reduce the hazard to the water plant operator, fluorosilicic acid (hydrofluosilicic acid) must not be diluted. Instead, the metering pump specified shall permit the use of undiluted fluorosilicic acid for water plants of any size.
    2. No more than a 30-hour supply of fluorosilicic acid should be connected at any time to the suction side of the chemical feed pump. All systems using bulk storage tanks must have a day tank.
    3. Day tanks or direct acid-feed carboys/drums shall be located on scales; daily weights shall be measured and recorded. Volumetric measurements, such as marking the side of the day tank, are not adequate for monitoring acid feed systems.
    4. Full spill containment shall be provided for bulk storage tanks. Furthermore, bulk storage facilities cannot be located over plant treatment basins, pumping wells, transfer wells or clearwells.
    5. Bulk storage tanks inside buildings; day tanks and unsealed carboys shall be vented to the outside with a vent approved by the department.

e. Dry Fluoride Feed Systems.
    1. Dry feeders (both volumetric and gravimetric) must be provided with a solution tank.
    2. Solution tanks shall be sized according to Water Fluoridation: A Manual for Engineers and Technicians published by the Centers for Disease Control and Prevention.
    3. A mechanical mixer should be used in every solution tank of a dry feeder when sodium fluorosilicate is used.
    4. Scales must be provided for weighing the amount of chemicals used in the dry feeder.

f. Testing Equipment.
    1. Surface water plants should use the ion electrode method of fluoride analysis.
    2. A magnetic stirrer should be used in conjunction with the ion electrode method of fluoride analysis.
    3. The colorimetric method (SPADNS) of fluoride analysis can be used where no interference occurs or where the interferences are consistent (e.g., from iron, chloride, phosphate, sulfate, or color).

g. Secondary controls. Secondary control systems for fluoride chemical feed devices may be required by the department as a means of reducing the possibility for overfeed.

h. Protective equipment. The use of personal protective equipment (PPE) is required when fluoride compounds are handled or when maintenance on fluoridation equipment is performed. The employer should develop a written program regarding the use of PPE and make this a part of the operation plan for the system. Safety procedures should be routinely followed and enforced.

1. Fluorosilicic acid.

   a. At a minimum, the operator shall be provided with the following personal protective equipment for normal maintenance and operation of fluorosilicic acid facilities:

      i. Gauntlet neoprene gloves with cuffs, which should be a minimum length of 12 inches (30.5 cm);

      ii. Full face shield and splash-proof safety goggles; and

      iii . Heavy-duty, acid-proof neoprene apron or acid-proof clothing and shoes.

   b. Specific procedures for handling leaks in bulk storage tanks must be included in the required, system, emergency operations plan.

   c. A safety shower and an eye wash station must be available and easily accessible.

2. Sodium fluoride or sodium fluorosilicate. An eye wash station should be available and easily accessible. The operator shall be provided with the following personal protective equipment:

   a. A National Institute for Occupational Safety and Health (NIOSH)/Mine Safety and Health Administration (MSHA)-approved, N-series particulate respirator (i.e., chemical mask) with a soft rubber face-to-mask seal and replaceable cartridges (49-51);

   b. Splash-proof safety goggles;

   c. Gauntlet neoprene gloves, which should be a minimum length of inches (30.5 cm); and

   d Heavy-duty, acid-proof neoprene apron.

3. Dust control.

   a. Provision must be made to minimize fluoride dust when transferring dry fluoride compounds from shipping containers to storage bins or hoppers. Feeder hoppers shall be provided with an exhaust fan and dust filter that place the hopper under a negative pressure. Air exhausted from the fluoride handling equipment shall discharge through a dust filter to the outside atmosphere of the building.

   b. Provision shall be made for disposing of empty bags, drums, or barrels in a manner that will minimize exposure to fluoride dusts. A floor drain should be provided to facilitate the hosing of floors.

5.5. Ozone

5.5.1. Ozone Generator

a. Capacity.
   1. The production rating of the ozone generators shall be stated in pounds per day and kw-hr per pound at a maximum cooling water temperature and maximum ozone concentration.
   2. The design shall ensure that the minimum concentration of ozone in the generator exit gas will not be less one percent, by weight.
   3. Generators shall be sized to have sufficient reserve capacity so that the system does not operate at peak capacity for extended periods of time, which can result in premature breakdown of the dielectrics.
   4. The production rate of ozone generators will decrease with a variation in the supply temperature of the coolant throughout the year. Curves or other data shall be used to determine production changes due to the temperature change of the supplied coolant. The design shall ensure that the generators can produce the required ozone at maximum temperature.
   5. Appropriate ozone generator backup equipment must be provided.

b. Electrical.
   The generators can be low, medium or high frequency type. Specifications shall require that the transformers, electronic circuitry and other electrical hardware be proven, high quality components designed for ozone service.

c. Cooling. The required water flow to an ozone generator varies with the ozone production. Normally unit design provides a maximum cooling water temperature rise of 2.8°C (5°F). The cooling water must be properly treated to minimize corrosion, scaling and microbiological fouling of the water side of the tubes. A closed loop cooling water system is often used to ensure proper water conditions are maintained. Where cooling water is treated cross connection control shall be provided to prevent contamination of the potable water supply.

d. Materials. To prevent corrosion, the ozone generator shell and tubes shall be constructed of Type 316L stainless steel**.**

5.5.2. Ozone Contactors.

The selection or design of the contactors and method of ozone application depends on the purpose for which the ozone is being used.

a. Bubble Diffusers. Where disinfection is the primary application, a minimum of two contact chambers, each equipped with baffles to prevent short-circuiting and induce countercurrent flow, shall be provided. Ozone shall be applied using porous-tube or dome diffusers.

b. The minimum contact time shall be ten minutes. A shorter contact time may be approved if justified by appropriate design and CT considerations.

c. For ozone applications in which precipitates are formed , such as with iron and manganese removal, porous diffusers should be used with caution.

d. Where taste and odor control is of concern, multiple application points and contactors shall be considered.

e. Contactors should separate closed vessels that have no common walls with adjacent rooms. The contactors must be kept under negative pressure and sufficient ozone monitors shall be provided to protect worker safety. Placement of the contactors where the entire roof is exposed to the open atmosphere is recommended. In no case shall the contactor roof be a common wall with a separate room above the contactors.

f. Large contact vessels should be made of reinforced concrete. All reinforcement bars shall be covered with a minimum of 1.5 inches of concrete. Smaller contact vessels can be made of stainless steel, fiberglass or other material which will be stable in the presence of residual ozone and ozone in the gas phase above the water level.

g. Where necessary a system shall be provided between the contactors and the off-gas destruction unit to remove froth from the air and return the other to the contactors or other location acceptable to the reviewing authority. If foaming is expected to be excessive, then a potable water spray system shall be placed in the contactors head-space.

h. All openings into the contactors for pipe connections, hatchways, etc. shall be properly sealed using welds or ozone resistant gaskets such as Teflon or Hypalon.

i. Multiple sampling ports shall be provided to enable sampling of each compartment's effluent water and to confirm CT calculations.

j. A pressure/vacuum relief valve shall be provided in the contactors and piped to a location where there will be no damage to the destruction unit.

k. The diffusion system should work on a countercurrent basis such that the ozone is fed at the bottom of the vessel and water is fed at the top of the vessel.

l. The depth of water in bubble diffuser contactors should be a minimum of 18 feet. The contactors should have a minimum of 3 feet of freeboard to allow for foaming.

m. All contactors shall have provisions for cleaning, maintenance and drainage of the contactors. Each contactor compartment shall be equipped with an access hatchway.

n. Aeration diffusers shall be fully serviceable by either cleaning or replacement.

o. Other Contactors. Other contactors, such as the venturi or aspirating turbine mixer contactors, may be approved by the department provided adequate ozone transfer is achieved and the required contact times and residuals can be verified.

5.5.3. Ozone Destruction Unit.

A system for treating the final off-gas from each contactor must be provided in order to meet safety and air quality standards. Acceptable systems include thermal destruction and thermal/catalytic destruction units. In order to reduce the risk of fires, the use of units that operate at lower temperature is encouraged, especially where high purity oxygen is the feed gas. The maximum allowable ozone concentration in the discharge is 0.1 ppm (by volume). At least two units shall be provided which are each capable of handling the entire gas flow. Exhaust blowers shall be provided in order to draw off-gas from the contactors into the destruction unit. Catalysts must be protected from froth, moisture, and other impurities that may harm the catalyst. The catalyst and heating elements shall be located where they can easily be reached for maintenance.

5.5.4. Piping Materials.

Only low carbon 304L and 316L stainless steels shall be used for ozone service with 316L the preferred.

5.5.5. Joints and Connections.

Connections on piping used for ozone service are to be welded where possible. Connections with meters, valves, or other equipment are to be made with flanged joints with ozone resistant gaskets, such as Teflon or Hypalon. Screwed fittings shall not be used because of their tendency to leak. A positive closing plug or butterfly valve plus a leak-proof check valve shall be provided in the piping between the generator and the contactors to prevent moisture reaching the generator.

5.5.6. Instrumentation.

Pressure gauges shall be provided at the discharge from the air compressor, at the inlet to the refrigeration dryers, at the inlet and outlet of the desiccant dryers, at the inlet of the ozone generators and contactors and at the inlet to the ozone destruction unit. Electric power meters should be provided for measuring the electric power supplied to the ozone generators. Each generator shall have a trip which shuts down the generator when the wattage exceeds a certain preset level. Dew point monitors shall be provided for measuring the moisture of the feed gas from the desiccant dryers. Because it is critical to maintain the specified dew point, it is recommended that continuous recording charts be used for dew point monitoring which will allow for proper adjustment of the dryer cycle. Where there is potential for moisture entering the ozone generator from downstream of the unit or where moisture accumulation can occur in the generator during shutdown, post-generator dew point monitors shall be used. Air flow meters shall be provided for measuring air flow from the desiccant dryers to each of other ozone generators, air flow to each contactor and purge air flow to the desiccant dryers. Temperature gauges shall be provided for the inlet and outlet of the ozone cooling water and the inlet and outlet of the ozone generators feed gas, and, if necessary, for the inlet and outlet of the ozone power supply cooling water. Water flow meters shall be installed to monitor the flow of cooling water to the ozone generators and, if necessary, to the ozone power supply. Ozone monitors shall be installed to measure ozone concentration in both the feed-gas and off-gas from the contactors and in the off-gas from the destruction unit. For disinfection systems, monitors shall also be provided for monitoring ozone residuals in the water. The number and location of ozone residual monitors shall be such that the amount of time that the water is in contact with the ozone residual can be determined. A minimum of one ambient ozone monitor shall be installed in the vicinity of the contactors and a minimum of one ambient ozone monitor shall be installed in the vicinity of the generator. Ozone monitors shall also be installed in any areas where ozone gas may accumulate.

5.5.7. Alarms.

The alarm/shutdown systems listed here should be considered at each installation.

a. Dew point shutdown/alarm. This system should shut down the generator in the event the system dew point exceeds-60 °C (-76 °F).
b. Ozone generator cooling water flow shutdown/alarm. This system should shut down the generator in the event that cooling water flows decrease to the point that generator damage could occur.
c. Ozone power supply cooling water flow shutdown/alarm. This system should shut down the power supply in the event that cooling water flow decreases to the point that damage could occur to the power supply.
d. Ozone generator cooling water temperature shutdown/alarm. This system should shutdown the generator if either the inlet or outlet cooling water exceeds a certain preset temperature.
e. Ozone power supply cooling water temperature shutdown/alarm. This system should shutdown the power supply if either the inlet or outlet cooling water exceeds a certain preset temperature.
f. Ozone generator inlet feed-gas temperature shutdown/alarm. This system should shutdown the generator if the feed-gas temperature is above a preset value.
g. Ambient ozone concentration shutdown/alarm. The alarm should sound when the ozone level in the ambient air exceeds 0.1 ppm or a lower value chosen by the water supplier. Ozone generator shutdown should occur when ambient ozone levels exceed 0.3 ppm (or a lower value) in either the vicinity of the ozone generator or the contactor.
h. Ozone destruct temperature alarm. The alarm should sound when temperature exceeds a preset value.

5.5.8. Safety.

The maximum allowable ozone concentration in the air to which workers may be exposed must not exceed 0.1 ppm (by volume). Noise levels resulting from the operating equipment of the ozonation system shall be controlled to within acceptable limits by special room construction and equipment isolation. High voltage and high frequency electrical equipment must meet current electrical and fire codes. Emergency exhaust fans must be provided in the rooms containing the ozone generators to remove ozone gas if leakage occurs. A portable purge air blower that will remove residual ozone in the contactors prior to entry for repair or maintenance should be provided.

5.5.9. Construction Considerations.

Prior to connecting the piping from the desiccant dryers to the ozone generators the air compressors should be used to blow the dust out of the desiccant. The contactors should be tested for leakage after sealing the exterior. This can be done by pressurizing the contactors and checking for pressure losses. Connections on the ozone service line should be tested for leakage using the soap-test method.

5.6. Ozone Feed Gas Preparation

Feed gas can be air, high purity oxygen, or oxygen enriched air. Air handling equipment on conventional low pressure air feed systems shall consist of an air compressor, water/air separator, refrigerant dryer, heat reactivated desiccant dryer, and particulate filters. Some “package” ozonation systems for small systems may work effectively operating at high pressure without the refrigerant dryer and with a “heat-less” desiccant dryer. In all cases the design engineer must ensure that the maximum dew point of -60°C (-76° F) will not be exceeded at any time. For oxygen-feed systems, dryers typically are not required.

5.6.1. Air Compression.

a. Air compressors shall be of the liquid-ring or rotary lobe, oil-less positive displacement type for smaller systems or dry rotary screw compressors for larger systems.
b. The air compressors shall have the capacity to simultaneously provide for maximum ozone demand, provide the airflow required for purging the desiccant dryers (where required) and allow for standby capacity.
c. Air feed for the compressors shall be drawn from a point protected from rain, condensation, mist, fog, and contaminated air sources to minimize moisture and hydrocarbon content of the air supply.
d. A compressed air after-cooler and/or entrainment separator with automatic drain shall be provided prior to the dryers to reduce the water vapor.
e. A back-up air compressor must be provided so that ozone generation is not interrupted in the event of a break-down.

5.6.2. Air Drying.

a. Dry, dust free and oil- free feed gas must be provided to the ozone generator. Dry gas is essential to prevent formation of nitric acid, to increase the efficiency of ozone generation, and to prevent damage to the generator dielectrics. Sufficient drying to maximum dew point of -60° C (-76 degrees ° F) must be provided at the end of the drying cycle

b. Drying for high pressure systems may be accomplished using heatless desiccant dryers only. For low pressure system, a refrigeration air dryer in series with heat-reactivated desiccant dryer shall be used.

c. A refrigeration dryer capable of reducing inlet air temperature to 4° C (40° F) shall be provided for low pressure air preparation systems. The dryer can be of the compressed refrigerant type or chilled water type.

d. For heat-reactivated desiccant dryers, the unit shall contain two desiccant filled towers complete with pressure relief valves, two four-way valves and a heater. In addition, external type dryers shall have a cooler unit and blowers. The size of the unit shall be such that the specified dew point will be achieved during a minimum adsorption style time of 16 hours while operating at the maximum expected moisture loading conditions.

e. Multiple air dryers shall be provided so that the ozone generation is not interrupted in the event of dryer breakdown.

g. Each dryer shall be capable of venting "dry" gas to the atmosphere, prior to the ozone generator, to allow start-up when other dryers are "on-line."

5.6.3. Air Filters.

a. Air filters shall be provided on the suction side of the air compressors, between the air compressors and the dryers and between the dryers and the ozone generators.

b. The filter before the desiccant dryers shall be of the coalescing type and be capable of removing aerosol and particulate larger than 0.3 microns in diameter. The filter after the desiccant dryer shall be of the particulate type and be capable of removing all particulate greater than 0.1 microns in diameter, or smaller if specified by the generator manufacturer.

5.6.4. Air Preparation Piping.

Piping in the air preparation system can be common grade steel, seamless copper, stainless steel or galvanized steel. The piping must be designed to withstand the maximum pressures in the air preparation system.

Chapter 6 -- Minimum Construction Requirements for Pumping Facilities

6.0 General

This section applies to community water systems that construct or make major modifications to pumping facilities.

6.01. National Standards.

a. Unless otherwise noted in this document, design and construction of the following components shall be in accordance with the latest edition of the American Water Works Association (AWWA) Standards:

1. AWWA Standard E101 for Vertical Turbine Pumps-Line Shaft and Submersible Types;
2. AWWA Standard C500 for Metal Seated Gate Valves for Water Supply Service;
3. AWWA Standard C509 for Resilient Seated Gate Valves for Water Supply Service;
4. AWWA Standard C504 for Rubber Seated Butterfly Valves;
5. AWWA Standard C507 for Ball Valves 6-inch Through 48-inch;
6. AWWA Standard C508 for Swing-Check Valves for Water Works Service 2-inch Through 24-inch;
7. AWWA Standard C115 for Flanged Ductile Iron Pipe with Ductile-Iron or Gray-Iron Threaded Flanges;
8. AWWA Standard C200 for Steel Water Pipe 6-inch and Larger;
9. AWWA Standard C206 for Field Welding of Steel Water Pipe;
10. AWWA Standard C207 for Steel Pipe Flanges for Water Works Services Sizes 4-inch Through 144-inch; and
11. AWWA Standard C220 for Stainless-Steel Pipe 4-inch and Larger.

b. Centrifugal Pumps.
Unless otherwise noted in this document, centrifugal pumps shall be designed and constructed in accordance with the latest Hydraulic Institute Standards B73.1 (horizontal types) or B73.2 (vertical types), except that the following requirements shall be observed:

1. Larger stuffing boxes for mechanical seals shall be used;
2. Solid Shafts shall be used for close coupled, end suction, horizontal centrifugal pumps to eliminate bending motion caused by the impeller; and
3. Close coupled, end suction, horizontal centrifugal pumps should not be used if the L^3/D^4 ratio is greater than 60 where L is shaft length and D is shaft diameter.

c. Electrical Equipment.
Unless otherwise noted in this document, design and construction of all electrical equipment and all wiring associated with pumping facilities shall be in accordance with the latest NFPA 70 National Electric Code

published by the National Fire Protection Association and shall be in accordance with any applicable local electric code or portion of a local electric code that is more stringent than the National Electric Code. In addition, pump motors shall meet applicable requirements of the Federal Energy Policy and Conservation Act and rules of the United States Department of Energy on efficiency requirements of electric motors.

d. Buildings.
Unless otherwise noted in this document, design and construction of buildings that house pumping facilities should be such that the structure will have a NFPA Type I (443) construction rating as outlined in the latest NFPA 270 Standard on Types of Building Construction published by the National Fire Protection Association.

e. Ladders, Stairways, Handrails and other Safety Equipment.
Unless otherwise noted in this document, design and construction of all ladders, stairways, handrails, safety cages, and other safety appurtenances for pumping facilities shall conform to the latest federal Occupation Safety and Health Administration (OSHA) Regulation 29 CFR, Part 1910, Occupational Safety and Health Standards, General Industry Standards. These safety appurtenances shall also conform to any applicable local ordinances, codes, standards or portion thereof that are more stringent than the OSHA standards.

f. Other Pumping Equipment.
Pumps, valves, pipe, and appurtenances other than those listed above in the national standards may be used in pumping facilities provided the engineer demonstrates that the components have sufficient strength, durability, and functionality. Some specialty components not listed in the national standards may be more appropriate, such as stainless steel, nickel-copper alloy or low-zinc bronze bolts for flanged piping to reduce corrosion or globe valves when throttling is needed. In these cases, the most appropriate component is recommended. Solvent welded polyvinylchloride (PVC) pipe shall not be used.

6.02. Other General Standards.

a. Pumping facilities shall be designed to maintain the sanitary quality of the pumped water. No pumping station shall be subject to flooding. Subsurface pits or pump rooms should be avoided.

b. Electrical efficiency of the pumping system should be considered in pump design and overall electrical usage and electrical cost as affected by electrical peak demand considerations should be minimized.

c. Preliminary pump curves and system curves including suction pressures shall be provided as part of a complete hydraulic analysis showing conditions for all possible combinations of pumps in operation. This information shall be provided as part of the plans and specification submittal.

d. As part of the final as-built plans or certification submitted by the engineer for pumping facilities projects, the department shall be provided with manufacturer, model number, impeller size, horsepower, voltage and amperage requirements for both unsteady state (startup) and steady state conditions, rotational speed(s), electrical phase requirements, pump curve showing both head versus flow characteristics and efficiency characteristics, and life expectancy with proper maintenance for each pump and motor. The department shall also be provided with final cost of the project, excluding land and easement.

6.1. Location.

6.1.1. The pumping station shall be so located that the proposed site will meet the requirements for sanitary protection of water quality, hydraulics of the system, and protection against fire, flood, vandalism, terrorist acts, or other hazards.

6.1.2. Site protection shall include the following:

a. The pumping station shall be elevated to a minimum of four feet above the 100 year return frequency flood elevation or four feet above the highest historical flood elevation, whichever is higher, or protected to such elevations;

b. The pumping station shall be readily accessible to operating and maintenance personnel at all times unless the overall system design allows the station to be out of service for the period of inaccessibility;

c. The area around the pumping station shall be graded to route surface water drainage away from the station; and

6.1.3. Pumping stations shall be protected against vandalism, sabotage, terrorist acts, or entrance by unauthorized personnel. See section 2.5. for specific requirements and recommendations.

6.2. Pumping Stations.

6.2.1. Finished and raw water pumping stations.

a. Both finished and raw water pumping stations shall be designed and constructed to include adequate space for the installation of additional units that may be needed during the next 20 years and adequate space around each unit to allow safe servicing;

b. Buildings should be of durable construction with a life expectancy with proper maintenance of 100 or more years. This shall include structural design to withstand all 100- year return frequency weather related events except a direct hit by a tornado;

c. Buildings shall have outward opening doors;

d. Floors shall be at least six inches above finished grade;

e. Underground structures shall be water-proofed;

f. All floors shall be drained in such a manner that the quality of potable water shall not be endangered. All floors shall slope at least 1:40 vertical to horizontal (3 inches per 10 feet) to a suitable drain;

g. Water from pump gland drainage shall be discharged through a suitable outlet without discharging to the floor;
h. Hose bibs to provide water for cleaning shall be provided; and
i. Smooth nose sample tap constructed of brass, bronze, or stainless steel shall be located on each pump discharge to allow bacterial sampling.

6.2.2. Suction wells.

Suction wells shall be designed and constructed to protect the quality of water pumped including the following:

a. Suction wells shall be water tight;
b. Suction wells shall have floors sloped to permit removal of water and solids;
c. Suction wells shall be covered or otherwise protected against contamination; and
d. Suction wells shall have baffles, adjustable false walls, or other appurtenances necessary to prevent vortexing.

6.2.3. Motor and Pump Installation and Removal.

a. Pump stations shall be designed and constructed to allow the safe, efficient removal and reinstallation of each motor and pump including:
    i. Crane ways, hoist beams with hoists, eyebolts, or other facilities shall be provided for lifting, removing, and reinstalling each equipment item that weighs 50 or more pounds; and
    ii The buildings shall be equipped with openings in floors, roofs, or walls to allow safe, efficient removal and reinstallation of equipment. These openings shall be properly hatched, grated, or doored to protect the building from weather or unauthorized entry when not in use.
b. Maintenance equipment, including a tool board, should be provided.

6.2.4. Stairways/Ladders.

Pump stations shall be equipped with permanent stairways and ladders to allow access to every part of the building that must be entered for operation or maintenance of the equipment. Stairways shall be provided to areas that must be routinely entered.

6.2.5. Heating, Ventilation, Lighting, and Dehumidifying.

Pump stations shall be equipped with heating, ventilation, lighting, and dehumidification for the safe, efficient operation and maintenance of the equipment and reasonable comfort of the operator including the following:

a. Heating equipment shall be installed in facilities that are manned less than one hour per day to maintain a temperature of 40 degrees Fahrenheit (40º F) or higher during the 100-year return frequency coldest temperature;

b. Heating equipment shall be installed in facilities that are manned one hour per day or more to maintain a temperature of 65 degrees Fahrenheit (65º F) or higher during the 100-year return frequency coldest temperature;

c. Ventilation (and air conditioning if needed) shall be provided that achieves the following:

    1. Inside temperature and outside temperature shall not have a differential of more than 10º F during the 100-year return frequency hottest temperature;
    2. Inside temperature shall be maintained lower then the highest allowable ambient operating temperature for each pump motor, and electrical component;
    3. All rooms, compartments, pits, and enclosures below ground level shall be power vented to provide at least six air changes per hour. Switches to operate the ventilation equipment and lights shall be located at the entrance to the below ground facility and shall be placed to allow these to be operated without entering the facility; and
    4. All rooms, compartments, pits, and enclosures that are subject to accumulation of hydrogen sulfide (H_2S), chlorine gas (Cl_2), radon (Rn), or other hazardous substances shall have air changes sufficient to maintain levels of each hazardous substance below the eight hour daily exposure Occupation Safety and Health Administration (OSHA) limit but in no case less than six air changes per hour; and

d. Lighting shall be provided so that every part of the facility is well lit and all instrument readings and all maintenance and operation can be performed without additional lighting. Light fixtures shall be located where bulbs can be readily changed.

6.2.6. Dehumidification.

Dehumidification should be provided if ventilation is not adequate to prevent condensation that is causing a safety hazard or is damaging equipment or controls.

6.2.7. Manned pumping stations.

Pumping stations that are manned for one hour or more per day shall be equipped with potable water, lavatory, and toilet facilities. Plumbing must be installed so as to prevent contamination of the public water supply and wastes shall be discharged in accordance with regulations in 10 CSR 20.

6.3. Pumps.

6.3.1.

Pumps shall be sized as part of the overall public water supply design to meet maximum day pumping demand, diurnal peak flow, instantaneous peak flow, fire flow (if provided), and minimal flows. At least two pumping units shall be provided and the pumps shall be capable of meeting maximum day pumping demand with the largest capacity pump out of service. When pumping units are required to operate over a broad flow range, a sufficient number of single speed pumps with different flow capabilities or variable speed pumps shall be provided. If single speed pumps are provided, they shall be sized to provide the entire range of flow and to avoid excessively short run cycles. Frequently used single speed pumps should be provided in pairs. Variable speed pumps shall be provided in pairs. Any submittal for variable speed or frequency pumps shall include system curves covering the entire flow range and shall specify the base horsepower and base speed required. All specifications for variable frequency drives shall require fault protection for power circuit components and harmonic distortion protection to protect the drive and power system ahead of the drive. Before any variable speed pump is approved, variable torque curves showing that the pump motor will produce enough torque and volt/frequency/torque curves shall be submitted.

6.3.2.

Public water systems that have pressure planes served by a single tower shall have pumps able to meet all water demands and maintain adequate main pressure while the tower is out of service for maintenance. These pumps shall be equipped with permanent pressure relief devices.

6.3.3. Pumping unit design and construction.

a. Pumps shall have ample capacity to supply the peak demand without dangerous overload. Pumps should be designed to operate in the head/flow range of maximum efficiency.

b. Prime movers driving pumps shall be able to operate against the maximum head.

c. Spare parts and tools needed for routine maintenance and repair of pumps and motors shall be readily available.

d. Control equipment shall have the proper heater and overload protection of the air temperature extremes expected.

e. Pumps that generate 30 pounds per square inch (psi) or more surge pressure during start up or shutdown or which generate surges that result in pressure below 20 per square inch gage (20 psig) anywhere in the distribution system shall be equipped with water hammer/surge protection devices and these devices shall be designed to reduce surge pressure to less than thirty pounds per square inch (30 psi) and maintain distribution pressure of twenty pounds per square inch gage (20 psig) or more.

6.3.4. Suction Lift.

a. Suction lift should be avoided if possible.
b. Suction lift shall be within allowable limits of the pump and preferably less than 14 feet.
c. Provisions shall be made for priming pumps providing suction lift. Prime water must not be of lesser sanitary quality than the water being pumped. Means shall be provided to prevent back siphonage. When an air operated ejector is used, the screened intake shall draw clean air from a point at least ten feet above the ground or other possible contamination unless the air is filtered by an apparatus approved by the department. Vacuum priming may be used.

6.4. Additional Requirements for Booster Pumps.

In addition to meeting the pump requirements in section 6.3. of this document, booster pumps shall meet the criteria in this section.

6.4.1. Booster pumping station

Each booster pumping station shall contain not less than two pumps with capabilities such that peak demand and fire flow, if provided, can be satisfied with the largest pump out of service. The booster station shall also include equipment such as multiple sets of pumps with different capacities, variable speed pumps, hydropneumatic tanks, or other equipment to meet the full range of flow needed if elevated storage is not provided to stabilize pressure on the portion of the distribution system served;

6.4.2. Booster Pumps Drawing from Storage Tanks

6.4.2.1. Booster pumps drawing from storage tanks.

Booster pumps drawing from storage tanks shall be located and controlled to achieve the following:

a. Pumps will not produce negative pressure in the suction line;
b. All pumps shall be valved and piped so that each pump can be isolated and removed with the remaining pumps in service;
c. Automatic or remote control devices shall have a range between start and cutoff pressure which will prevent excessive cycling; and
d. All booster pumping stations shall contain a totalizing meter.

6.4.2.2. Suction lines.

Suction lines should be buried but shall be protected from freezing temperatures if not buried.

6.4.3. Inline booster pumps

Inline booster pumps are pumps that do not draw water directly from storage.

a. Distribution systems with inline booster pumps shall not cause main pressures to drop below 20 psig in any part of the system delivering water to the booster station.
b. All pumps shall be accessible for servicing and shall be valved and piped so that each pump can be isolated and removed with the remaining pumps in service.

6.4.4. Individual home booster pumps

Individual home booster pumps shall not be allowed for any individual service from the public water supply mains unless approved by the department. Approval will generally be considered only for temporary service until properly designed distribution system improvements can be made to eliminate the low pressure area.

6.4.5. Automatic stations

All automatic stations should be provided with automatic signaling apparatus that will report when the station is out of service. All remote-controlled stations shall be electrically operated and controlled and shall have signaling apparatus of proven performance.

6.5. Appurtenances.

6.5.1. Valves.

a. Pumps shall be adequately valved to permit satisfactory operation, maintenance, and repair of the equipment. If foot valves are necessary, they shall have a net valve area of at least 2½ times the area of the suction pipe and they shall be screened. Each pump shall have a positive-acting check valve on the discharge side between the pump and the shut-off valve.
b. Pressure control valves shall be required for reducing water hammer or surges that equal or exceed 30 pounds per square inch and shall be required if the surge results in pressure below 20 pounds per square inch gage anywhere in the distribution system.

6.5.2. Piping.

In general, piping shall:

a. Be designed so that the friction losses will be minimized;

b. Not be subject to contamination;
c. Have watertight joints;
d. Be protected against surge or water hammer;
e. Be such that each pump has an individual suction line or that the lines shall be so manifolded that they will ensure similar hydraulic and operating conditions;
f. Be equipped with a hose bib for cleaning; and
g. Be equipped with smooth-nose sampling taps constructed of brass, bronze, or stainless steel on both the suction and discharge.

6.5.3. Gauges and meters.

Each pump:

a. Shall have a standard pressure gauge on its discharge line;
b. Shall have a compound gauge on its suction line;
c. Shall have recording gauges in the stations with capacities of 0.5 million gallons per day (MGD) or larger; and
d. Should have a totaling time of operation meter.

6.5.4. Water Seals.

a. Water seals shall not be supplied with water of a lesser sanitary quality than that of the water being pumped.
b. Where pumps are sealed with potable water and are pumping water of lesser sanitary quality, the seal shall:
    1. Be provided with a break tank open to atmospheric pressure;
    2. Have an air gap of at least one inch or two pipe diameters, whichever is greater, between the feeder line and the spill line of the tank; or
    3. Provided with a reduced pressure principle backflow prevention assembly.

6.5.5. Controls.

Pumps, their prime movers, and accessories, shall be controlled in such a manner that they will operate at rated capacity without dangerous overload. Where two or more pumps are installed, provision shall be made for alternating pumps. Provision shall be made to prevent energizing the motor in the event of a backspin cycle. Electrical controls shall be located above grade.

6.5.6. Power.

For their own protection, all water systems should make an arrangement for back-up power. Systems serving a population of 3,300 or more shall make arrangements for back-up power, and include these arrangements in their emergency operating plan. When power failure would result in cessation of minimum essential service, power supply should be provided from at least two independent sources or a standby or an auxiliary source should be provided. Portable auxiliary power generators may be used if they are sized to generate sufficient power for normal operation of the pumping station. Pumping stations to be served by portable power generators should be equipped with permanent in-place electric connections and controls for operating on the power generator. Systems with multiple booster pumping stations should have a power supply from at least two independent sources, permanent onsite standby or auxiliary power sources or portable generators for each booster pumping station that serves more than 100 connections.

6.5.7. Water pre-lubrication.

When automatic pre-lubrication of pump bearings is necessary and an auxiliary direct drive power supply is provided, the pre-lubrication line shall be provided with a valved bypass around the automatic control so that the bearings can, if necessary, be lubricated manually before the pump is started, or the pre-lubrication controls shall be wired to the auxiliary power supply.

Chapter 7 -- Minimum Construction Standards for Finished Water Storage Tanks and Reservoirs

7.0. General Design and Construction Standards

7.0.1. AWWA Standards for Unpressurized Tanks and Reserviors

Unless otherwise noted in this rule, unpressurized tanks and reservoirs for finished water storage shall be designed and constructed in accordance with the latest edition of the American Water Works Association (AWWA) standards, as follows:

Welded Steel Tanks for Water Storage	AWWA Standard D100
Coatings for Steel Water Storage Tanks	AWWA Standard D102
Factory Coated Bolted Steel Tanks for Water Storage	AWWA Standard D103
Automatically Controlled Impressed Current Cathodic Protection for the Interior of Steel Water Tanks	AWWA Standard D104
Wire and Strand Wound Circular, Pre-stressed Concrete Water Tanks	AWWA Standard D110
Circular Pre-stressed Concrete Water Tanks with Circumferential Tendons	AWWA Standard D115

7.0.2. Parameters for Unpressurized Tanks and Reservoirs for Finished Water Storage

These parameters should be considered during the design of unpressurized tanks and reservoirs for finished water storage.

a. Tank design should be part of a unified long range, engineering design that includes wells, treatment plants, high service pumps, booster pumps, and distribution mains. Since tanks have an approximate useful life of 50 years, the design should consider future growth, including the elevation of areas likely to be developed during the useful life of the tank. Current service area and future service area should be divided into appropriate pressure zones with operating pressures between 35 psig and 100 psig. All of these items should be reflected in the design to ensure the tank will not become obsolete during its useful life.

b. The tank should be designed to maintain water temperature above 32˚ F during the winter weather that would result in the lowest storage water temperature during a seven-day period taken from the most recent 100-year period of weather data or statistically calculated as a 100-year return frequency. An energy balance should be calculated using the following parameters: average winter (December, January, February) daily flow into and out of the tank; winter diurnal flow pattern into and out of the tank; water temperature into the tank under the winter design conditions; heat transfer between the water layer and air layer in the tank; heat transfer rate through the tank wall and any insulating layer; heat transfer from the outside tank surface to the atmosphere based on wind speed and air temperature from the winter design conditions; solar energy input to the tank during daylight under the winter design conditions; and radiation heat loss from the tank to the sky during night time under winter design conditions. If winter design conditions are not available, a reasonably conservative estimate can be made using the high and low temperature from the record low temperature day from the nearest U. S. weather station with 100 years of record for one of the seven days, using the average coldest winter day from the nearest U. S. Weather station with 100 years of record for the other six days, using sunrise/sunset times and sun angle for the seven days centered on the winter solstice, using average wind speed for December – February from the nearest U. S. Weather station with 100 years of record, and assuming 50% cloud cover for sky conditions. This energy balance should be used to set the winter tank turnover rate, winter pump ON/pump OFF elevations, inlet and outlet designs to ensure mixing to minimize ice formation, insulation requirements (if appropriate) and heater requirements (if appropriate).

c. The tank should be designed to turn over a sufficient percentage of the stored water daily to minimize aesthetic water quality problems. This percentage may vary with local condition, but a 25% daily turnover is suggested as a default value. Note that additional turnover may be required for winter operations to minimize freezing. Separate inlet and outlet lines should be provided.

7.0.3. Location

a. The bottom of reservoirs and standpipes and footings for elevated tanks shall be above the 100 year return frequency flood level and shall be above the highest known historic flood elevation. Top of footings for elevated tanks shall be at least one foot above the finished grade.

b. The bottom of reservoirs and standpipes and footings for elevated tanks shall be above the true ground water level.

c. The bottom of reservoirs and standpipes should be placed above the normal ground surface. When the bottom must be placed below ground surface, sewers, drains, standing water and similar sources of contamination must be kept at least 50 feet from the reservoir except that specially constructed gravity sewers may be located no closer than 20 feet from the reservoir. These specially constructed gravity sewers shall be made of water main pipe pressure tested in place to 50 psig pressure without leakage. The top of the reservoirs shall not be less than two feet above the normal ground surface except that clear wells under filters may be exempted when the total design gives the same protection. The area surrounding a ground level structure shall be graded in a manner that will prevent surface water from standing within 50 feet of it. Steel storage tanks shall not be located below the ground surface.

7.0.4. Roofs on Unpressurized Finished Water Storage Structures

All unpressurized finished water storage structures shall have suitable watertight roofs that prevent entrance of birds, animals, insects, and excessive dust. The roof shall be well drained. Downspouts shall not enter or pass through the storage structure.

7.0.5. Protection of Finished Water Storage Structures

All finished water storage structures shall be protected from trespassing, vandalism, and sabotage. Protection shall include at least the following:

a. Locked hatches and other access openings;
b. Physical barriers to entrance of ladders; and
c. Security fencing with locked gates.

See also section 2.5, Security Measures.

7.0.6. Vents on Unpressurized Finished Water Storage Structures

All unpressurized finished water storage structures shall be vented. Overflows shall not be considered vents. Open construction between the sidewall and roof is not permissible. Vents shall meet the following criteria:

a. Vents shall be sized with sufficient capacity to pass air so that the maximum flow of water entering or leaving the tank will not cause excessive pressure or vacuum. Maximum flow of water leaving the tank shall include the rate produced by a catastrophic large main failure near the tank. Resistance of air flow caused by the vent screens shall be considered in sizing the vents;
b. Vents shall be designed to exclude precipitation, shall be screened to exclude birds, insects, and animals and shall terminate a minimum of 24 inches above the roof. Eighteen mesh noncorrodible screen may be used. The finished water storage structure shall also be equipped with a pressure-vacuum relief mechanism that will operate should the finer mesh screens be frost plugged or clogged with foreign material. The primary purpose of the vents is to prevent catastrophic structural failure of the tank caused by pressure differential. No modifications shall be made to vents to interfere with this primary purpose; and
c. Clearwell vents shall vent to the outside.

7.0.7. Overflows on Unpressurized Finished Water Storage Structures

All unpressurized finished water storage structures shall be provided with an overflow. Overflows shall meet the following criteria:

a. Overflows shall be sized to permit the waste of water in excess of the maximum filling rate with a head not more than six inches above the lip of the overflow. Resistance of flow through the screen or flap shall be considered in sizing the overflow;
b. Overflows shall be brought down to an elevation between 12 and 24 inches above the ground surface, shall terminate at the bottom with an elbow directed away from the foundation, and shall discharge over a drainage inlet structure or splash plate. Overflows shall not be directly connected to a sewer or storm drain;
c. Overflows shall be protected from entrance of birds or animals by a tight fitting counterweighted flap valve. Overflows should be diverted to minimize property damage and inconvenience to adjacent property owners; and
d. Overflows shall be provided for all clearwells.

7.0.8. Freeze Protection for Unpressurized Finished Water Storage Structures

All unpressurized finished water storage structures and their appurtenances including the internal structural components riser pipes, overflows, vents, and hatches shall be designed to prevent freezing that will interfere with proper functioning or cause structural damage to the storage vessel. Design shall be based on a 100 year return frequency extended low temperature period and average wind velocity.

7.0.9. Catwalks

Every catwalk over finished water in a storage structure shall have a solid floor with raised edges so designed that shoe scrapings and dirt will not fall into the water.

7.0.10. Corrosion Protection

Proper protection shall be given to metal surfaces. Tanks constructed of steel, wrought iron, or other metals subjects to corrosion shall have both interior and exterior surfaces painted, except that bottoms of reservoirs and standpipes should not be painted.

a. Exterior paint should contain less than 100 milligrams of lead per kilogram of dried paint to prevent removed paint from being classified as a hazardous waste.
b. Exterior paint color should be chosen to help manage the temperature of stored water to reduce freezing or reduce excessive summer temperatures as needed.
c. Interior paint systems shall be certified for drinking water use under the latest ANSI/NSF Standard 61.
d. Interior paint systems shall be properly applied and cured and shall not transfer any substance to the water that results in a violation of a maximum contaminant level or secondary contaminant level outlined

in 10 CSR 60, Chapter 4. Curing should also be done to eliminate tastes and odors. After painting and proper curing are completed and the tank is filled, the water that exhibits such odors shall be tested for each paint constituent that is listed in 10 CSR 60, Chapter 4 prior to placing the tank in service.

e. Tanks constructed of corrosion resistant metals shall be designed to meet the same structural requirements outlined in section 2.1.1. and shall not be required to be painted. Corrosion resistant metals shall be chosen to resist corrosion from all naturally occurring chemicals in the water stored, all chemicals added as part of water treatment including the addition of chlorine and other disinfectants, and the natural atmosphere including current and expected future air pollutants in the area.

7.0.11. Drains on Unpressurized Tanks and Reservoirs

Unpressurized tanks and reservoirs shall be equipped with a drain and have facilities for collecting bacteriological samples.

a. Elevated tanks and standpipes with a nominal capacity of 30,000 gallons or more that provide pressure by gravity shall be equipped with a fire hydrant with one pumper (steamer) nozzle of approximately 4½ inches in diameter and two hose nozzles of approximately 2½ inches diameter. The piping, valves, and fire hydrant shall be designed and constructed to allow the tank to be taken off line and drained through the fire hydrant.
b. Other above ground tanks shall be equipped with a fire hydrant or flush hydrant. The piping, valves, and hydrant shall be designed and constructed to allow the tank to be taken offline and drained through the flush hydrant or fire hydrant.
c. No drain shall have a direct connection to a sewer or storm drain. The design and construction shall allow tanks and reservoirs to be taken offline, drained, cleaned, repaired, and painted without causing loss of pressure in the distribution system.

7.0.12. Roofs and Sidewalls on Unpressurized Tanks and Reservoirs

Unpressurized tanks and reservoirs shall have roofs and sidewalls designed and constructed to preserve the quality of the water stored.

a. The roof and sidewalls must be water tight with no openings except properly constructed vents, manways, overflows, risers, drains, pump mountings, control ports, or piping for inflow and outflow.
b. Any pipes running through the roof or sidewall of a finished water storage structure must be welded or properly gasketed in metal tanks. In concrete tanks these pipes shall be connected to standard wall castings. These wall castings should have seepage rings imbedded in the concrete.
c. Openings in a structure roof or top designed to accommodate control apparatus or pump columns shall be curbed and sleeved with proper

additional shielding to prevent the access of surface or floor drainage water into the structure.

d. Valves and controls shall be located outside the storage structure so that the valve stems and similar projections will not pass through the roof or top of the reservoir.

7.0.13. Access to Unpressurized Finished Water Storage Structures

Unpressurized finished water storage structures shall be designed and constructed to allow convenient access to the interior for cleaning and maintenance. The number, location, and spacing of hatches and manways shall conform to the federal Occupational Safety and Health Administration (OSHA) regulation 29 CFR, Part 1910. Roof or top hatches shall be framed at least six inches above the surface of the roof or top at the opening, shall be fitted with a solid, water tight, hinged cover which overlaps the framed opening and extends down around the frame at least two inches, and shall have a locking device.

7.0.14. Discharge Pipes

The discharge pipes from all reservoirs shall be located in a manner that will prevent the flow of sediment into the distribution system. Removable silt stops should be provided.

7.0.15. Safety Devices at Unpressurized Finished Water Storage Structures

Unpressurized tanks and reservoirs shall be equipped with safety devices to allow safe inspection, repairs, maintenance, and painting.

a. Ladders, handrails, safety cages and other safety appurtenances shall conform to the federal OSHA regulation 29 CFR, Part 1910. These safety appurtenances shall also conform to any applicable local ordinances, codes, or standards that are more restrictive than OSHA standards. No wire, cable or other device shall be attached to the ladders, handrails or other safety appurtenances in such a manner that will obstruct or impair the safe use of these devices.
b. Ladders, ladder guards, balcony railings, and safely located entrance hatches shall be provided where applicable.
c. Railings or handholds shall be provided on elevated tanks where persons must transfer from the access tube to the water compartment.
d. Elevated tanks with riser pipes over eight inches in diameter shall have protective bars over the riser opening or a safety handrail around the riser opening inside the tank.
e. Warning lights should be provided on standpipes and elevated storage tanks and shall be provided when required by the Federal Aviation Administration (FAA) or local codes.

f. Cables, power conduits, antenna brackets or similar devices shall be installed inside properly constructed conduits. Properly designed brackets must secure these to the storage structure.

7.0.16. Disinfection of Unpressurized Finished Water Storage Structures

Disinfection of unpressurized finished water storage tanks and reservoirs following construction, repairs, painting, or other maintenance shall be done in accordance with the latest edition of the AWWA Standard for Disinfection of Water-Storage Facilities, AWWA C652.

a. At least one sample shall be analyzed to indicate microbiologically satisfactory water before the facility is placed into operation.
b. Disposal of chlorinated water from the tank shall be in accordance with Missouri Clean Water Commission requirements to protect aquatic life.

7.1. Tanks and Reservoirs for Finished Water Storage

7.1.1. Fire Protection.

Public water supplies that provide fire protection shall have finished water storage tanks, reservoirs, and other facilities with sufficient capacity to provide minimum design needed fire flow for the length of fire duration and shall provide adequate storage to meet diurnal peak flow with fire flow being considered.

a. The minimum allowable design needed fire flow and design supply works capacity are 250 gallons per minute for a fire duration of two hours.
b. Other commonly used design needed fire flows with the equivalent fire durations are listed in section 7.5.

7.1.2. No Fire Protection.

Public water supplies that do not provide the fire protection shall have sufficient finished water storage to meet the minimum design operating pressure and flow for the diurnal flow pattern on the design maximum usage day with all well pumps, treatment plants, high service pumps, booster pumps, or other equipment that affect pressure and flow in operation. This can be achieved by the following methods:

single well operation

a. Provide finished water elevated storage with nominal capacity equal to or greater than one day's average demand. For standpipes, the volume above the elevation, which provides 20 psig at the tower base, shall be counted as nominal capacity. (This method does not require documentation or estimation of diurnal flow pattern or design maximum day usage.)

b. Provide ground level finished water storage with nominal capacity equal to or greater than one day's average demand. Duplex high service pumps with capacity capable of meeting design instantaneous peak flow with the largest pump out of service shall be provided with this option. Note the volume above low level withdrawal pump shut down is counted as nominal capacity. (This method does not require documentation or estimation of diurnal flow pattern or design maximum day's usage.)

c. Estimate or document diurnal flow pattern and design maximum day's usage. Calculate the minimum nominal finished water storage needed to maintain design operating pressure and flow with all well pumps, treatment plants high service pumps, booster pumps or other equipment that affect pressure and flow in operation. The minimum storage needed will vary for each public water supply but 25% of design maximum day's usage is a reasonable default value.

multiple well operation

d. Provide hydropneumatic storage as outlined in section 7.4.

7.1.3. Tank and Reservoir Capacity for Unpressurized Tanks

Tank and reservoir capacities estimated in engineering design studies and finalized in engineering final plans and as-built plans submitted to the department shall include the elevation and volume data specified here.

7.1.3.1. Elevations.

All of the elevations specified here, expressed to the nearest 0.1 feet above mean sea level (msl), shall be provided for all nonpressurized tanks. For preliminary engineering designs, the msl elevations may be estimated from United States Geological Survey (USGS) 7.5 minute Quadrangle maps but the public water supply, the engineer and the funding agency must recognize that this method of estimating elevations is subject to significant error and corrections of preliminary errors in elevation on elevated tanks may substantially change the cost of the project. For final engineering plans and as-built plans, the msl elevations shall be determined by measurement from a known USGS or department elevation monument.

1. Elevation of the finished grade (ground surface) at the base or under the tank.
2. Elevation of the actual tank bottom.
3. Elevation of the bottom capacity level (point at which the tank normally discharges).
4. Elevation at which the withdrawal pumps shut down because of low level (applicable to tanks/reservoirs with withdrawal pumps).
5. Elevation which will provide twenty pounds per square inch gage (20 psig) static pressure at finished grade at the base of the tank (applicable to standpipes that provide pressure by gravity).
6. Elevation which will provide twenty pounds per square inch gage (20 psig) static pressure at the highest surface elevation in the area to be served by the tank (applicable to standpipes that provide pressure by gravity.

Schedule JAM-4

7. Elevation at which the filling pump starts (or the filling control valve opens).
8. Elevation at which the filling pump stops (or filling control valve closes).
9. Elevation at which the tank/reservoir begins to overflow.
10. Elevation at the top of the tank or reservoir (or roof of the tank or reservoir).

7.1.3.2. Volumes.

All of volumes specified here, expressed to the nearest 100 gallons, shall be provided for all unpressurized tanks.

1. Volume between the elevations of the bottom capacity level (point at which the tank normally discharges) and the elevation at which the tank begins to overflow (applicable to elevated tanks). This is the nominal capacity for elevated tanks.
2. Volume between the elevation of the bottom capacity level (point at which the tank normally discharges) and the elevation at which the filling pump starts (or filling control valve opens). This is the available fire suppression volume for elevated tanks.
3. Volume between the elevation that will provide 20 psig static pressure at finished grade at the base of the tank and the elevation at which the tank begins to overflow (applicable to standpipes that provide pressure by gravity). This is the nominal capacity for standpipes.
4. Volume between the elevation that will provide 20 psig static pressure at finished grade at the base of the tank and the elevation at which the filling pump starts (or the filling control valve opens). This is the available fire suppression volume for standpipes.
5. Volume between the elevation at which the withdrawal pumps shut down because of low level and the elevation at which the reservoir begins to overflow (applicable to reservoirs/tanks with withdrawal pumps). This is the nominal capacity for reservoirs.
6. Volume between the elevation at which the withdrawal pumps shut down because of low level and the elevation at which the filling pump starts (or the filling control valve opens). This is the fire suppression volume for reservoirs.
7. Volume between the elevation at which the filling pump starts (or the filling control valve opens) and the elevation at which the filling pump stops (or the filling control valve closes). This is the turnover volume for tanks/reservoirs used to assess filling pump run lengths and heat loss/ice formation calculations.
8. In addition to the above volume information, the engineer shall submit a table or graph as part of the as-built plans that shows tank volume from actual tank bottom to the overflow in increments no greater than one foot elevation change. The basis for this table or graph shall be identified and geometric calculations shown or actual metered volumes listed.

7.1.4. Costs

As part of the final engineering certification on a tank/reservoir construction project, the engineer shall submit the final cost of the tank excluding land or easement costs.

7.2. Plant Storage

These requirements are in addition to the applicable requirements listed in subsections 7.0. and 7.1.

7.2.1. Filter Backwash.

Wash water tanks shall be sized to provide the filter backwash at the design filter backwash rate. The wash water tanks, pumps, and finished water storage must be designed to allow backwashing several filters in rapid succession in order to meet the most extreme plant operational problems expected. Plants with three or fewer filters should have sufficient wash water capacity to backwash all filters in rapid succession.

7.2.2. Clear Wells.

Clear wells shall be designed and constructed as part of the overall design of plant and distribution facilities to provide adequate disinfection, adequate backwash volume, and adequate distribution flow and pressure.

7.2.3.1. A suitable vent(s) and overflow shall be provided.

7.2.3.2. Disinfectant contact time shall meet the requirements of the January 1992 Missouri Department of Natural Resources' Public Drinking Water Program Guidance Manual for Surface Water System Treatment Requirements and 10 CSR 60-4.055 Disinfection Requirements.

7.2.3.3. Clearwell storage should be sized in conjunction with distribution system storage to allow constant rate plant operation without intermittent shutdowns. A minimum of two clear well compartments should be provided.

7.2.3.4. Clearwell storage should be sized to allow the flexibility of one, two, or three eighth-hours shifts per day operation.

7.2.3. Receiving Basins and Pump Wet Wells

Receiving basins and pump wet wells for finished water shall be designed as finished water storage structures.

7.2.4. Finished Water Adjacent to Unsafe Water

Finished water must not be stored or conveyed into a compartment adjacent to unsafe water when the two compartments are separated by a single wall.

7.3. Distribution Storage

These requirements are in addition to the applicable requirements listed in subsections 7.0. and 7.1.

7.3.1. Minimum PSIG at Normal Ground Elevation

Distribution storage shall be designed and constructed in conjunction with production facilities, pumping facilities, and distribution mains to provide a minimum of 35 psig pressure at the normal ground elevation at every point of the distribution system during all conditions of design flow. Normal operating conditions include extended drought usage and diurnal peak flow.

7.3.2. Working Pressure PSIG at Normal Ground Elevation

Distribution storage should be designed and constructed in conjunction with production facilities, pumping facilities, and distribution mains to provide a working pressure of 60 psig at the normal ground elevation at every point in the distribution system during all normal operating conditions except fire flow.

a. Areas with elevation differences of more than 150 feet should be divided into multiple pressure zones so that each zone has pressure between 35 and 100 psig.
b. Multiple pressure zone systems should have separate storage facilities for each zone and should be equipped so that water can be transferred between zones with pump stations and pressure control valves.
c. Each public water system shall be designed to maintain normal system pressures and flows with any storage facility out of service for maintenance or should have at least two storage tanks or reservoirs so that removing a tank or reservoir for maintenance will not disrupt distribution system pressure.

7.3.3. Distribution Storage Controls

Distribution storage facilities shall be equipped with adequate controls to maintain levels in the tanks/reservoirs.

a. Level indicating devices should be located at a central location.
b. Pumps should be controlled from tank levels with the signal transmitted by telemetering equipment when any appreciable head loss occurs in the distribution system between the pump and the storage structure. Pressure control valves (usually installed on the discharge line and pump to waste line with a control system that opens and closes these valves simultaneous to control pressure surge/water hammer) should be installed on pumps when pumps and storage facilities are not adjacent.
c. Overflow and low level warnings or alarms should be located at places in the community where these will be under responsible surveillance 24 hours per day.

7.4. Hydropneumatic Storage

7.4.1. Hydropneumatic storage.

Hydropneumatic storage (pressure tanks or bladder tanks) shall not be used as the only storage facilities for community public water systems serving more than 50 connections.

7.4.2. Pressure tanks.

Pressure tanks shall be designed and operated so that one-third (1/3) of the total volume functions as a permanent water seal.

7.4.3. Boyle's Law.

Boyle's Law shall be used to design the volume of the gas phase of pressure tanks and bladder tanks.

Boyle's Law: $P_1V_1 = P_2V_2$

Where P is absolute pressure and V is volume.

For units of pounds per square inch, absolute pressure is: psia = psig + 14.7

Where psia indicates absolute pressure and psig indicates gage pressure.

For commonly used pressure ranges (pump on to pump off) and 1/3 total volume of pressure tanks used at water seal, the following table based on Boyle's Law may be used for design. Note that usable volume is also called drawdown volume and that bladder tanks have no permanent water seal.

Figure 4 - Hydropneumatic Tank Usable Volume

Tank Type		Pressure Range		
		20-40 psig	30-50 psig	40-60 psig
Pressure	Percent of total volume	42.29%	46.06%	48.82%
	Permanent gas cushion usable volume	24.38%	20.61%	17.85%
	Permanent water seal	33.33%	33.33%	33.33%
Bladder	Permanent gas cushion	63.44%	60.09%	73.23%
	Usable volume	36.56%	30.91%	26.77%

7.4.4 Pressure tanks or bladder tanks used as the only storage for small community water supplies.

Pressure tanks or bladder tanks used as the only storage for small community water supplies shall have a minimum usable volume of 6.25 gallons per person served. (Note this is equivalent to 35 gallons gross volume per person served when the pressure range is 40 to 60 psig and the water seal is 1/3 of the total volume for a pressure tank.)

7.4.5. Pressure/Bladder Tanks Used with Other Storage and Booster Pumps

Pressure tanks or bladder tanks used in conjunction with other storage and booster pumps and those used as the only storage for noncommunity public water supplies shall have a usable volume sufficient to store at least two minutes' discharge from the largest supplying pump.

7.4.6. Pressure Tanks -- Separate Inlet and Outlet Lines

Pressure tanks shall have separate inlet and outlet lines to provide positive flow through the tanks.

7.4.7. Bladder Tanks - Individually Connected

Bladder tanks shall be individually connected to the supply line to the distribution system to improve circulation to individual tanks.

7.4.8. Certification of Hydropneumatic Tanks

Hydropnuematic tanks shall be certified for drinking water use under the latest version of ANSI/NSF Standard 61.

7.4.9. Hydropneumatic Tank Design and Construction

Hydropneumatic tanks should be designed and constructed in accordance with the latest ASME Boiler and Pressure Vessel Code Section II, Part A, B, C, D, Section V, Section VIII Division I and Section IX published by the American Society of Mechanical Engineers.

7.4.10. Pressure Tanks That Provide Disinfection Contact Time

Pressure tanks that provide disinfection contact time shall be designed to meet requirements of the January 1992 Missouri Department of Natural Resources' Public Drinking Water Program Guidance Manual For Surface Water System Treatment Requirements and 10 CSR 60-4.055 Disinfection Requirements.

7.4.11. Pressure Tanks with Gross Volume of 1,000 Gallons or More

Pressure tanks with gross volume of 1,000 gallons or more per tank shall be designed and constructed with the following appurtenances and features:

a. Each tank shall have at least one manway with minimum diameter 24-inch clear opening for circular manways or 18 inches by 22 inches minimum dimensions for elliptical manways. Additions manways should be provided on larger tanks as needed for access and ventilation during painting;

b. Each tank shall have a water sight glass, a pressure gage, a mechanical means of adding air, a pressure blow off for excess air, and a drain. The drain shall discharge above the normal ground surface with no direct connection to a sewer or storm drain;

c. The piping connected to each tank shall be equipped with sufficient valves and bypass lines to allow the tank to be taken offline, drained, cleaned, repaired and painted without causing loss of pressure in the distribution system;

d. Each tank shall have adequate automatic controls to manage both the water level in the tank and the pressure of the air cushion; and

e. Each tank shall be sufficiently housed to protect all appurtenances and the tank from freezing. Each tank shall be located above the normal ground surface. Design shall be based on a 100-year return frequency extended low temperature period and average wind velocity.

7.4.12. Pressure and Bladder Tanks with Gross Volume of less than 1,000 Gallons

Pressure tanks and bladder tanks with gross volume less than 1,000 gallons per tank shall be designed and constructed with the following appurtenances and features:

a. Each tank shall be above the normal ground surface and completely housed in a heated building to prevent freezing;

b. The piping connecting tanks shall have sufficient valves and bypass lines to allow each individual tank to be taken offline, drained, repaired, painted, or replaced without causing loss of pressure in the distribution system;

c. The tanks shall be equipped with automatic controls to control pressure/water level in the tanks. A means to manage the volume and pressure of air in the air cushion of pressure tanks shall be provided but this may be done manually with portable equipment. There shall be at least one pressure gage in the tank manifold; and

d. Multiple tanks may be used to achieve the total design volume needed.

7.4.13. Protection to Metal Surfaces

Proper protection shall be given to metal surfaces of pressure tanks

a. Tanks constructed of steel or other metal subject to corrosion shall have both interior and exterior surfaces painted.
   1. Exterior paint should contain less than 100 milligrams of lead per kilogram of dried paint to prevent removed paint from being classified as a hazardous waste.
   2. Interior paint shall be certified for drinking water use under the latest ANSI/NSF Standard 61.

b. Tanks constructed of corrosion resistant metals shall not be required to be painted. Corrosion resistant metals shall be chosen to resist corrosion from all naturally occurring chemicals in the water stored, all chemicals added as part of water treatment including chlorine and other disinfectants and the natural atmosphere including current and expected future air pollutants in the area.

7.5. Fire Flow Information

7.5.1. Standard Fire Flow with Corresponding Fire Durations.

Standard fire flow with corresponding fire duration is indicated in the table here.

Figure 5 - Design Needed Fire Flow

Design Needed Fire Flow (gallons per minute)	Fire Duration (hours)
250	2
500	2
750	2
1,000	2
1,250	2
1,500	2
1,750	2
2,000	2
2,250	2
2,500	2
3,000	3
3,500	3
4,000	4
4,500	4
5,000	4
5,500	4
6,000	4
6,500	4
7,000	4
7,500	4
8,000	4
8,500	4
9,000	4
9,500	4
10,000	4
11,000	4
12,000	4

7.5.2. Fire Suppression Rating Schedule.

Public water supplies that provide fire protection should determine design needed fire flow and design supply works capacity in accordance with the latest Fire Suppression Rating Schedule published by Insurance Services Organization Inc. (ISO). Ideally, design supply works capacity should equal or exceed design needed fire flow.

7.5.3. Storage for Fire Flow

Storage for fire flow is only one of many components that must be assessed in the engineering design of public water supplies' fire suppression capability. Many other factors not related to water supply, including emergency communications capability, fire department capability, building code requirements, and zoning departments, influence fire suppression capability and ISO rating. All of these factors and local fire district requirements should be assessed in the engineering design for public water supply facilities that will support fire suppression. In general, public water supplies with populations greater than 250 persons and with service connection densities greater than 16 service connections per 160 acres should consider providing at least the levels of fire flow in the Table below.

Figure 6 - Population and Fire Flow

Population	Fire Flow in Residential Areas	Fire Flow in Commercial Areas
250-999	250 gpm for 2 hours	250 gpm for 2 hours
1,000 to 9,999	1000 gpm for 2 hours	2,500 gpm for 2 hours
10,000 and greater	1,500 gpm for 2 hours	3,500 gpm for 3 hours

Chapter 8 - Distribution Systems

8.0. Materials.

8.0.1. Standards and materials selection.

Pipes shall conform to the latest edition of the AWWA, ASTM, Plastic Pipe Institute (PPI), or UniBell Plastic Pipe Association standards or recommendations. Fittings, valves, and fire hydrants shall conform to the latest standards issued by the AWWA and shall be certified by NSF for use in drinking water. Special attention shall be given to selecting pipe materials that will protect against both internal and external pipe corrosion. PVC pipes that are less than three inches in diameter must be at least Class 200 and conform to SDR-21. PVC pipes three inches through 12 inches in diameter shall be no less than Class 160 and conform to SDR-26. Pipes, fittings, and appurtenances containing more than 8 percent lead shall not be used.

8.0.2 Permeation of pipe walls.

In areas that are contaminated with organic chemicals, permeation of organic chemicals into the water system shall be prevented by using non-permeable materials for all portions of the water system including pipe, fittings, service connections, and hydrant leads.

8.0.3. Used materials

Only water mains that been used previously for conveying potable water may be reused, and must meet the above standards and have been practically restored to their original condition.

8.0.4. Joints.

Packing and jointing materials used in the joints of pipe shall conform to the latest edition of the AWWA standards. Pipe having mechanical joints or slip-on joints with rubber gaskets is preferred.

8.1. Water Main Design

8.1.1. Pressure.

All water mains shall be sized in accordance with a hydraulic analysis based on flow demands and pressure requirements. The system shall be designed to maintain a minimum pressure of 35 psi at ground level at all points in the distribution system under all conditions of design flow not including fire flow, except that the department may approve a minimum design pressure of 20 psi in areas served by rural water districts. The normal working pressure in the distribution system should be approximately 60 psi.

8.1.2. Diameter.

a. The minimum size of a water main for providing fire protection and serving fire hydrants shall be six inches in diameter. Larger mains shall be required, if necessary, to allow withdrawal of the required fire flow while maintaining the minimum residual pressure of 20 pounds per square inch throughout the distribution system.
b. For public water systems not providing fire protection, no main shall be smaller than two inches in diameter.

8.1.3. Fire Protection

When fire protection is to be provided, system design should be such that fire flows and facilities meet the classification criteria of the state Insurance Services Office (ISO). Water mains not designed to carry fire-flows shall not have fire hydrants connected to them.

8.1.4. Flushing.

a. Flushing devices and valving shall be provided to allow every main in the distribution system to be flushed. Flushing devices should be sized to provide flows that will give a velocity of at least 2.5 feet per second in the water main being flushed.
b. In order to provide increased reliability of service and reduce head loss, dead ends shall be minimized by making appropriate tie-ins whenever practical.
c. Where dead-end mains occur, they shall be provided with an approved flushing device.
d. No flushing device shall be directly connected to any sewer.

8.2. Valves.

Sufficient valves shall be provided on water mains so that inconvenience and sanitary hazards to customers will be minimized during repairs. Valves should be located at not more than 500 foot intervals in commercial districts and at not more than one block (or 800 foot) intervals in residential or other districts. Where systems serve widely scattered customers and where future development is not expected, the valve spacing should be at every water main branch on both the feeder main and the branch line.

8.3. Fire Hydrants.

8.3.1. Location and spacing.

Hydrants should be provided at each street intersection and at intermediate points between intersections to meet the classification criteria of the state ISO. Generally, hydrant spacing may range from 350 to 600 feet, depending on the area being served.

8.3.2. Valves and nozzles.

Fire hydrants should have a minimum bottom valve size of at least five inches, one 4-1/2 inch pumper nozzle, and two 2-1/2 inch nozzles.

8.3.3. Hydrant leads.

The hydrant lead shall be a minimum of six inches in diameter and contain a shutoff valve.

8.3.4. Drainage.

A gravel pocket or dry well shall be provided unless the natural soils will provide adequate drainage for the hydrant barrel. Hydrant drains shall not be connected to or located within ten feet of sanitary sewers or storm drains.

8.4. Air Relief Valves; Valve, Meter and Blow-Off Chambers

8.4.1. Location.

At high points in water mains where air can accumulate, provisions shall be made to remove the air by means of manually operated hydrants or automatic air relief valves. Automatic air relief valves shall not be used in situations where flooding of the manhole or chamber may occur.

8.4.2. Piping.

The open end of an air relief pipe from automatic valves shall be extended to at least one foot above grade and provided with a screened, downward-facing elbow. The pipe from a manually operated valve shall be capped with a threaded removable cap or plug and should be extended to the top of the pit. Vaults or wells housing automatic air relief valves shall be drained to daylight with drains sized to carry the maximum output of the air relief valve.

8.4.3. Chamber drainage.

Chambers, pits, or manholes containing valves, blow-offs, meters, or other such appurtenances to a distribution system, shall not be connected directly to any storm drain or sanitary sewer, nor shall blow-offs or air relief valves be connected directly to any sewer. Such chambers or pits shall be drained to the surface of the ground or provided with sump.

8.5. Installation of Mains.

8.5.1. Standards.

Specifications shall incorporate the provisions of the AWWA standards and/or manufacturer's recommended installation procedures.

8.5.2. Bedding.

a. A continuous and uniform bedding shall be provided in the trench for all buried pipe. Backfill material shall be tamped in layers around the pipe, and to a sufficient height above the pipe that the pipe is adequately supported, stabilized, and protected. Rocks and hard objects larger than one inch diameter found in the trench shall be removed for a depth of at least six inches below the bottom of the pipe. Sand or other fine non-acidic granular material should be used for pipe bedding in high traffic areas. As an alternative, a chipper may be used on the trencher to prepare the soil removed from the trench as bedding in high traffic areas.
b. Width of trenches shall be at least four inches larger than the pipe's diameter.

8.5.3. Cover.

All water mains shall be covered with at least 42 inches of earth or other insulation to prevent freezing. Lesser cover depth may be accepted in certain areas as approved by the department.

8.5.4. Blocking.

All tees, bends, plugs, valves, and hydrants shall be provided with reaction blocking, tie rods, or joints designed to prevent movement. Pre-cast concrete blocks should not be used.

8.5.5. Pressure and leakage testing.

All types of installed pipe shall be pressure tested and leakage tested in accordance with the latest edition of AWWA Standard .

8.5.6. Disinfection.

All new, cleaned, or repaired water mains shall be disinfected in accordance with the latest edition of the AWWA Standard. The specifications shall include detailed procedures for the adequate flushing, disinfection, and microbiological testing of all water mains.

8.6. Separation of Water Mains, Sanitary Sewers and Combined Sewers

8.6.1. General.

The following factors should be considered in providing adequate separation:

a. Materials and type of joints for water and sewer pipes;
b. Soil conditions;
c. Service and branch connections into the water main and sewer line;
d. Compensating variations in the horizontal and vertical separations;
e. Space for repair and alterations of water and sewer pipes; and
f. Off-setting of water mains around manholes.

8.6.2. Parallel installation.

Water mains shall be laid at least ten feet horizontally from any existing or proposed sewer. The distance shall be measured edge to edge. In cases where it is not practical to maintain a ten-foot separation, the department may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such deviation may allow installation of the water main closer to a sewer, provided that the water main is laid in a separate trench or on an undisturbed earth shelf located on one side of the sewer and on either case, at such an elevation that the bottom of the water main is at least 18 inches above the top of the sewer. In areas where the recommended separations cannot be obtained, either the waterline or the sewer line shall be constructed of mechanical joint pipe or cased in a continuous casing.

8.6.3. Crossings.

Water mains crossing sewers shall be laid to provide a minimum vertical clear distance of 18 inches between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. At crossings, the full length of water pipe shall be located so both joints will be as far from the sewer as possible but in no case less than ten feet. Special structural support for the water and sewer pipes may be required. In areas where the recommended separations cannot be obtained either the waterline or the sewerline shall be constructed of mechanical joint pipe or cased in a continuous casing that extends no less than ten feet on both sides of the crossing.

8.6.4. Exception.

Any variance from the specified separation distances in paragraphs 8.6.2.and 8.6.3. must be submitted to the department for approval.

8.6.5. Force mains.

There shall be at least a ten-foot horizontal separation between water mains and sanitary sewer force mains and they shall be in separate trenches. In areas where these separations cannot be obtained, either the waterline or the sewer line shall be cased in a continuous casing.

8.6.6. Sewer manholes.

No waterline shall be located closer than ten feet to any part of a sanitary or combined sewer manhole.

8.6.7. Disposal facilities.

No waterline shall be located closer than 25 feet to any on-site wastewater disposal facility, agricultural waste disposal facility, or landfill.

8.7. Surface Water Crossings.

Surface water crossings, whether over or under water, present special problems. The department should be consulted before final plans are prepared. Positive joints shall be required in waterways and wet weather streams.

8.7.1. Above-water crossings.

The pipe shall be adequately supported and anchored, protected from damage and freezing and accessible for repair or replacement.

8.7.2. Underwater crossings.

a. Flowing streams.
   A minimum cover of four feet shall be provided over the pipe. When crossing water courses are greater than 15 feet in width, the following shall be provided:
   1. The pipe shall be of special construction, having flexible watertight joints**.** Steel or ductile iron ball-joint river pipe shall be used for open cut crossings. Restrained joint pipe may be used for open cut crossings, provided it is encased in a welded steel casing. Restrained joint or fusion weld pipe shall be used for bored crossings.
   2. Valves shall be provided at both ends of water crossings so that the section can be isolated for testing or repair; the valves shall be easily accessible and should not be subject to flooding; and the valve closest to the supply source shall be in an accessible location.
   3. Permanent taps shall be provided on each side of the valve within the manhole to allow insertion of a small meter to determine leakage and for sampling purposes**.**
   4. The stream crossing pipe or casing shall extend at least 15 feet

beyond the upper edge of the stream channel on each side of the stream.

b. Intermittent flowing streams.

1. Restrained joint pipe shall be used for all stream crossings;
2. The pipe shall extend at least 15 feet beyond the upper edge of the stream channel on each side of the stream.

8.8. Backflow Prevention.

The water system must be protected from introduction of contaminants by backflow in accordance with 10 CSR 60-11.010 Prevention of Backflow.

8.9. Water Services and Plumbing.

8.9.1. Plumbing.

8.9.1.1. Water services and plumbing shall conform to relevant local or state plumbing codes, or to the National Plumbing Code.

8.9.1.2. Solders and flux containing more than 0.2% lead shall not be used.

8.9.1.3. Plumbing fittings and fixtures not in compliance with standards established in accordance 42 U.S.C. 300g-6(e) shall not be used.

8.9.2. Booster pumps.

See Chapter 6 of this document.

8.10. Service Meters.

Each service connection shall be individually metered.

8.11. Water Loading Stations.

Water loading stations present special problems since the fill line may be used for filling both potable water vessels and other tanks or contaminated vessels. To prevent contamination of both the public supply and potable water vessels being filled, the following requirements shall be met in the design of water loading stations.

8.11.1. Backflow.

An appropriate backflow prevention arrangement shall be incorporated in the piping so there is no backflow to the public water supply.

8.11.2. Filling device.

A filling device shall be used so the hose does not extend into the water vessel to prevent contaminants being transferred from a hauling vessel to others subsequently using the station.

8.11.3. Hose length.

Hoses shall be short enough that they do not contact the ground or any constructed platform. Hanging brackets or rope and pulley hoist are acceptable.

PSC Staff highligting: Plant Capacity - 8.140 on Page 44

Rules of

Department of Natural Resources

Division 20—Clean Water Commission
Chapter 8—Design Guides

Title 10—DEPARTMENT OF NATURAL RESOURCES
Division 20—Clean Water Commission
Chapter 8—Design Guides

10 CSR 20-8.010 Design of Municipal Waste Stabilization Lagoons in Missouri
(Rescinded August 13, 1979)

AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.

10 CSR 20-8.020 Design of Small Sewage Works

PURPOSE: This rule sets out criteria as a guide in designing and constructing small sewage works. These criteria are not necessarily applicable to the design of works having daily flows in excess of 22,500 gallons per day. For works having larger flows, 10 CSR 20-8.110–10 CSR 20-8.220 reflect the minimum acceptable standards. This rule reflects the minimum requirements of the Missouri Department of Natural Resources for design, submission of plans, approval of plans and approval of completed small sewage works. These criteria are based on the best information presently available but they may be subject to periodic review and revision as additional information and methods appear. Deviation from minimum requirements will be allowed if sufficient documentation justifies the deviation. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. Others wanting to receive addenda or supplements should contact the Missouri Clean Water Commission to be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirely would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Missouri Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule unless the context clearly requires otherwise. Where used, the terms mean a mandatory requirement insofar as approval by the department is concerned unless justification is presented for deviation from the requirements. Other terms, such as should, recommend and preferred, indicate discretionary department requirements. Deviations are subject to individual consideration.

(2) General.

(A) Before work on engineering documents has begun, it is recommended that inquiry be made to the appropriate department office as to what effluent limitations the proposed facility will probably be required to meet. The engineer and applicant should also be aware that if a geological evaluation of the receiving stream or lagoon site is required it will take thirty to forty-five (30–45) days to receive the geological evaluation. In general the final engineering documents will not be reviewed until the other elements of a complete application have been received in accordance with 10 CSR 20-6.010 Construction and Operating Permits. All reports, plans and specifications shall be submitted at least sixty (60) days prior to the date upon which approval of the engineering documents by the department is desired or in accordance with NPDES or other schedules. For unusual or complex projects, it is suggested that the engineer meet with the appropriate department office to discuss the project and that preliminary reports be submitted for review prior to preparation of final plans and specifications.

(B) One (1) set of engineering documents should be submitted for formal approval. It shall include the engineer's report, if required, general layout and detailed plans, specifications and summary of design data. All engineering documents shall be prepared by a registered professional engineer licensed to practice in Missouri and shall bear the imprint of his/her seal and signature. If the engineering documents contain known deviations from the criteria contained in this rule, documentation and justification for the deviation should be submitted with the summary of design data. If stamped, approved copies of plans and specifications are desired, additional copies should be submitted with the original documents along with a letter indicating disposition of the extra set of plans and specifications.

(3) Engineer's Report. An engineer's report shall be submitted whenever required by the department, and for sewage works serving subdivisions or other expansible projects, or for projects which might be connected to a comprehensive system at a future date. The engineer's report referenced in subsections (2)(A) and (B) shall contain the information outlined in this section.

(A) Field Survey. The following items shall be determined and reported:

1. Nature and use of schools, resorts, subdivisions or establishments to be served by the proposed facilities;

2. Population to be served, present and ultimate, and in some cases, the twenty (20)-year population projection;

3. Character and quantity of wastes other than domestic sewage which will be discharged through the system, including present method of garbage disposal and the possibility of future disposal of garbage wastes with sewage. (Note: Method of garbage disposal is critical when designing treatment facilities to serve food service establishments.);

4. Existing sewage treatment facilities;

5. Consideration of the various sites available and the advantages of the one selected. The proximity of the site to buildings or developed areas and the possibilities of flooding of the plant site;

6. The proximity of wells, cisterns, supply lines or other water supply structures in relation to the sewage treatment facilities; and

7. The results of geological evaluations, detailed soils investigations and interpretation of any laboratory soils testing data taken from soil borings.

(B) Analysis of Field Survey Data. Review field findings to determine the best possible solution regarding location, type of treatment and population (present, twenty (20)-year projected and ultimate) to be served.

(C) Recommendations. Include recommendations in detail concerning the proposed treatment works and outline a plan for future extension of the works.

1. Alternate plans. Where two (2) or more solutions exist for a particular problem, each of which is feasible and practical, discuss the solutions and the reason for selecting the one (1) recommended.

2. Sewer system. Describe the drainage area and extent to which plans provide sewage facilities for future development.

3. Sewage treatment. Discuss the degree and type of treatment, reasons for adopting the proposed method and the provisions made for future needs.

4. Ownership and operation. State ownership and who will be responsible for the facility. Continuing authorities must be in accordance with 10 CSR 20-6.010(3).

(D) Industrial Wastewater Treatment Facilities. Industrial waste treatment facilities shall be designed based on a thorough evaluation of waste characteristics, waste treatability and

Schedule JAM-5

site characteristics. The content for engineering reports listed in 10 CSR 20-8.110 and the requirements in this rule should be considered. The engineering reports shall contain a detailed waste description, laboratory analyses and documentation of the treatability and potential environmental pathways for each constituent that may be present in the waste and wastewater. The engineering report shall include a discussion of any applicable effluent guidance documents by the United States Environmental Protection Agency. The engineering report shall also contain documentation as to whether the wastewater stream may be classified as a hazardous waste pursuant to 10 CSR 25-4.261. Industrial flows containing hazardous wastes shall comply with the requirements of the hazardous waste regulation in 10 CSR 25.

(4) General Layout. The general plans for sewage works shall show—

(A) Miscellaneous. A suitable title and the name of the school, resort, subdivision or institution, the scale in feet, a graphical scale, the north point, date, the name of the design engineer and the imprint of the engineer's professional seal. The scale for the plans should not be less than one hundred feet (100') or greater than three hundred (300') to the inch. The lettering and figures on the plans must be of appropriate size and of distinct outline. Datum used should be indicated.

(B) Existing or proposed buildings, roadways, recreation facilities and all water surfaces and streams shall be clearly shown. Contour lines at suitable intervals should be included on the general plan. Elevations should be referenced to United States Geological Survey datum. Elevations in flood plain areas shall be based on United States Geological data. The boundary line of the property or area to be served shall be shown.

(C) Existing Facilities. The location, size, length, slope and direction of flow of all existing sanitary and storm sewers affecting the proposed improvements shall be shown. A plot plan of the existing treatment works indicating the topography and arrangement of existing units shall be shown.

(D) Proposed Facilities. The location of all proposed sewers with size, grade, length and direction of flow shall be indicated. All manholes shall be numbered on the layout and subsequently numbered on the profile. The location of outlets, treatment units, manholes, lampholes, siphons, pumping stations and other accessories shall be shown. Suitable symbols appropriately referenced shall be shown in the title of all these works.

(E) Water Supply and Facilities. The location of all existing and proposed wells, cisterns, reservoirs or other sources of public, semi-public or private water supplies located within five hundred feet (500') of the proposed or existing sewerage works should be shown. The location of all existing or proposed pumps, distribution systems and any other water supply structures should be shown.

(5) Detailed Plans. All detailed plans shall be prepared on blue or white prints and shall be drawn to a suitable scale. Detailed plans for sewage works shall be shown.

(A) Sewers. A plan and profile of all sewers to be constructed shall be provided. Profiles should be on a horizontal scale of one hundred feet (100') to the inch and a vertical scale of ten feet (10') to the inch. Show all known structures above and below ground which might interfere with the construction. The manhole stationing, size of sewers, surface and invert manhole elevations and grade of all sewers between adjacent manholes must be shown on the profile. Construction details of all ordinary sewer appurtenances such as manholes, lampholes and inspection chambers must be shown.

(B) Sewage Pumping Stations. Complete details including elevations and provision for future pumps shall be shown.

(C) Sewage Treatment Works. Complete details including elevations shall be given for all treatment units.

(D) Location Map. The exact location of the project shall be shown on a United States Geologic Survey topographic map or other suitable map which provides the exact location.

(6) Specifications. Complete detailed specifications for the construction of sewers, sewage treatment plant and all appurtenances shall accompany the plans. Continuing authorities as described in 10 CSR 20-6.010 or private engineering firms may file for approval of their standard sanitary sewer construction specifications with this department. A minimum of two (2) copies of the proposed standard specifications shall be submitted. The standard specifications must contain the following:

(A) Certification statement by a registered professional engineer licensed to practice in Missouri including signature, number and date; and

(B) If the engineer preparing the specifications is not a permanent, full-time employee of the continuing authority submitting the specifications, then the governing body of the continuing authority submitting the specifications must also submit a resolution adopting the specifications submitted as the official specifications of the continuing authority. Upon arrival and acceptance of standard specifications for sanitary sewer construction, the department will not require submission of specifications with the plans. However, the department will require that all plans contain a statement that all construction shall be in accordance with the approved standard specifications currently on file with the department. Additional special provisions for a particular project can also be utilized in conjunction with approved standard specifications. The applicant should submit copies of the special provisions properly certified by an engineer. When a revision to approved standard specifications is required by revision of departmental standards or governing continuing authority initiative, three (3) copies of the revision, properly certified and adopted, shall be submitted.

(7) Summary of Design Data. A summary of design data shall accompany the plans and specifications and contain the following:

(A) Flow and waste load projections, including estimated daily flow and types of wastes other than domestic;

(B) Type and size of individual process units along with hydraulic and organic loading to each individual unit. Show process diagrams, including flow diagram with capacities. Show the basic calculations and assumptions used to size each unit;

(C) Basic calculations for detention times in each process unit and the process as a whole. Discuss other considerations such as recycle, chemical additive control, physical control, flexibility and flow metering if applicable;

(D) Expected removals and expected effluent concentration of the permit limited contaminants in the discharge from the treatment facility; and

(E) Design calculations, tabulations and assumptions for the sewer lines and pump stations.

(8) Revisions to Approved Plans. Any deviations from approved plans or specifications affecting capacity, flow or operation of units must be approved in writing before these changes are made. Plans or specifications so revised should therefore be submitted well in advance of any construction work which will be affected by these changes to allow sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flow or operation will be permitted during construction without approval. As-built plans clearly showing these alterations shall be placed on file with the department after the completion of the work.

(9) Sewers. Sewers serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.120 Design of Sewage Works. Privately-owned systems or collection systems for schools, resorts or establishments of similar nature shall meet the following requirements:

(A) General. In general the department will approve plans for new systems, extensions to new areas or replacement of sanitary sewers only when designed upon the separate plan in which rainwater from roofs, streets and other areas and groundwater from foundation drains and springs are excluded.

1. Design period. Sewers should be designed for the estimated ultimate tributary population.

2. Materials. Any generally accepted material for sewers will be given consideration but the materials selected should be adapted to local conditions, special care being given to possibilities of septicity, excessive external loadings, abrasions, soft foundations and similar problems. All sewer pipes shall be covered by an applicable American Society for Testing and Materials (ASTM) standard. All sewers shall be designed to prevent damage from superimposed loads. Proper allowance for loads on the sewer due to width and depth of trench shall be made. All pipe used shall comply with applicable ASTM standards. Thin-walled drain, waste and vent piping shall not be used for sewers.

3. Joints and infiltration. The method of making joints and the materials used shall be included in the specifications. Materials used in jointing shall have satisfactory records for preventing infiltration and the entrance of roots. Portland cement mortar joints are not acceptable. The amount of leakage under wet weather conditions shall not exceed two hundred (200) gallons per inch diameter per mile of sewer per day.

4. Water and sewer separation. There shall be no permanent physical connection between a potable water supply and any sewer, treatment device or appurtenances thereto which will permit the passage of sewage or contaminated water into the potable water supply. Whenever possible, sewers and manholes should be located at least ten feet (10') horizontally from any existing or proposed water line. Should local conditions prevent a lateral separation of ten feet (10'), a sewer may be laid closer than ten feet (10') from a water main if it is in a separate trench or if it is in the same trench with the waterline located at one (1) side on a bench of undisturbed earth. In either case the elevation of the crown of the sewer must be at least eighteen inches (18") below the invert of the water line. Whenever sewers must cross under water lines and the sewer cannot be buried to meet these requirements, the water line shall be relocated to provide this separation or the sewer line constructed of slip-on or mechanical joint cast iron pipe, asbestos cement pressure pipe or PVC pressure pipe for a distance of ten feet (10') on each side of the water line and be pressure tested to assure watertightness.

5. Sewers in relation to streams. The top of all sewers entering or crossing streams shall be at sufficient depth below the natural bottom of the stream bed to protect the sewer line. The top of the sewer pipe should be a minimum of three feet (3') below the natural stream bottom. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible. Sewers entering or crossing streams shall be constructed of cast iron or ductile iron pipe with mechanical joints or shall be constructed so they will remain watertight and free from displacement. In stream beds consisting of loose or unconsolidated materials consideration must be given to the possible impeding effect the sewer line will have on water movement in the bed material. The sewer must be designed to present as little impedance as possible while maintaining structural integrity. Aerial sewer line crossing of streams shall be in accordance with 10 CSR 20-8.120.

(B) Sewer Design. The sewer must have sufficient capacity to carry one hundred gallons (100 gals.) per contributing person per day at the established grade with a peaking factor of four (4). Minimum allowable size of pipe for schools, resorts and similar establishments is six inches (6"). For subdivisions located in rural areas, the minimum allowable sewer size is six inches (6"). For subdivisions in metropolitan areas, or in rural areas adjacent to regional systems where incorporation into a regional system is feasible, the minimum allowable sewer size shall be eight inches (8"). In very small installations four-inch (4") diameter sewers may be used to carry raw sewage or settled sewage. No more than three (3) mobile homes or campsites or a four (4)-unit apartment house may be connected to a four-inch (4") line. The use of a four-inch (4") sewer line should be limited to one hundred fifty feet in length.

1. Depth. The sewer should be sufficiently deep to drain basements. Where cover of less than thirty inches (30") is necessary and justified, the sewer must be protected to prevent its being damaged from superimposed loads or freezing.

2. Velocity of flow. All sewers carrying raw sewage shall be so designed and constructed to give mean velocities when flowing full of not less than two feet (2') per second based on Manning's equation using an "n" value of 0.013. The following are the minimum slopes which should be provided:

Sewer Size (Raw Sewage)	**Slope, feet/100 feet**
4 inch	1.0
6 inch	0.60
8 inch	0.40

Sewer Size (Settled Sewage)	**Slope, feet/100 feet**
4 inch	0.5
6 inch	0.3
8 inch	0.2

3. Bedding. Concrete or well graded granular material (bedding classes A, B or C, as described in ASTM C12-74 or WPCF MOP No. 9) should be used for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load. Concrete or well graded granular material (bedding classes I, II or III, as described in ASTM D2321) should be used for all flexible pipe, provided the proper strength pipe is used with the specified bedding to support the anticipated load.

(C) Manholes. Manholes shall be installed at all changes in grade, size or alignment at all intersections and at distances of not greater than four hundred feet (400'). Cleanouts may be installed at the ends of laterals not exceeding one hundred fifty feet (150') in length.

1. Drop type. A drop pipe shall be provided for sewers entering a manhole at an elevation twenty-four inches (24") or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than twenty-four inches (24"), the invert shall be filleted to prevent solids deposition.

2. Diameter. The inside diameter of manholes shall not be less than forty-eight inches (48"). The manhole shall be sufficiently large to permit rodding and other maintenance work. Consideration should be given to larger diameters for shallow manholes under four feet (4'). Cleanouts shall be a minimum of eight inches (8") in diameter.

3. Flow channel. The flow channel through a manhole shall be made to conform in shape and slope to that of the sewer and shall be finished to provide a roughness coefficient as nearly as possible equal to that of

the sewer pipe. Where a bend occurs, the channel shall be curved uniformly from inlet to outlet. Changes in direction of flow should generally not exceed ninety degrees (90°). Where a junction of two (2) or more lines occurs, a separate channel shall be constructed for each incoming line with the channels gradually merging together ahead of the outlet using uniform curves. In general, the invert of any branch sewer should be slightly higher than the invert of the main sewer to avoid slack-water areas where solids may accumulate. The bench on either side of the flow channel should provide a secure footing for maintenance personnel and have enough slope to drain. A slope of one-half to one inch (.5–1.0") per foot is recommended.

4. Watertightness. Manholes shall be of the precast concrete or poured in place concrete type. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Locked manhole covers may be desirable in isolated locations where vandalism may be a problem.

5. Frame and cover. The frame and cover shall be of standard design with a minimum clear opening of twenty-two inches (22"). The frame and cover shall be designed as a unit. The cover shall be easily removable with the aid of ordinary hand tools, such as a pry bar. The cover shall be tight fitting and exclude surface water. The joint between the frame and manhole shall be watertight.

(D) Pressure Sewer Systems. A pressure sewer system is considered as two (2) or more individual pressurization units, such as grinder pumps, discharging into a common force main. Pressure sewer systems are not to be used in lieu of conventional gravity sewers but may be acceptable when it can be shown in the engineer's report that it is not feasible to provide conventional gravity sewers. When pressure sewer systems are utilized, the operating authority shall be responsible for the maintenance and operation of the individual pressurization units. When considering the use of a pressure sewer system, the problems of extreme flow variation and anaerobic conditions of the wastewater entering the treatment facility must be taken into consideration. Consideration shall also be given to the possible need for odor control facilities at receiving manholes or at the treatment facility. For pressure sewer systems to function as intended, all clear water from footing drains, basement sumps, leaky house connections and any other sources must be eliminated.

1. Design factors. Pressure sewer systems shall be laid out in a branched or tree configuration to avoid flow-splitting at branches which cannot be accurately predicted. The required pipe size shall be determined on the basis of three (3) principal criteria:

A. Velocities adequate to assure scouring should be achieved. A velocity of two to five feet (2–5') per second must be achieved at least once and preferably several times per day based on design flow.

B. Design shall be for peak sewage flow rates and negligible infiltration. Design shall be based on cumulative flow within the system. Infiltration and inflow must be considered when systems are being designed for existing residences where there is a potential for leaky house connections or leaky septic tanks.

C. Head loss should not exceed the pumping pressure capabilities. Head loss determination should be based on total dynamic head under the maximum flow expected to occur infrequently. It is recommended that a Hazen-Williams coefficient of one hundred twenty (120) be used to determine frictional head loss.

2. System arrangement. All pressure sewer pipe shall be installed at a depth sufficient to protect against freezing and mechanical damage. Attention must be given to the necessity for providing automatic air release valves at changes in slope. Release devices are required when the liquid flow velocity is insufficient to purge bubbles of trapped air. Pressure and/or flow control valves shall be installed at the end of all critical surge pipe runs in order to maintain a full pipe system and eliminate lift station flooding or plant washout. Water/sewer line crossings shall be in accordance with paragraph (9)(A)4. of this section.

3. System pressures. Pressure sewer system operating pressures in general should be in the range of twenty to forty pounds per square inch (20–40 lbs. psi) and shall not exceed sixty pounds per square inch (60 lbs. psi) for any appreciable amount of time. Provisions shall be made in both the system and the grinder pumps to protect against the creation of any long-term high pressure situations.

4. Materials. Many types of pipe materials may be used for pressure sewers. However, maximum benefit from the pressure approach can usually be achieved with nonmetallic materials such as polyethylene, fiberglass reinforced plastic and polyvinyl chloride. As a minimum the piping material should be equivalent to SDR 21 PVC pressure pipe. The small diameter service lines may be required to be constructed of a heavier pipe than SDR 21 PVC pressure pipe. Other materials may be used.

5. Service connections. Building service connections from individual grinder pumps to the collectors should be of one and one-fourth inch (1 1/4") PVC pipe and should include a full-ported valve (such as a corporation stop or "u" valve) located in the service line to isolate the pump from the main. Check valves specifically suited to wastewater service should be provided in the pressure service line before it enters the main.

6. Cleanouts and fittings. In place of manholes normally provided in gravity systems, pressure systems shall have cleanouts at intervals of approximately four hundred to five hundred feet (400–500'), at major changes of direction and where one (1) collector main joins another main. These cleanouts shall include an isolating valve and capped Y-branch fitting located on either side of the isolating valve and pointed both upstream and downstream for access during maintenance procedures.

A. Access for cleaning shall be provided at the upstream end of each main branch.

B. All appurtenances and fittings shall be compatible with the piping system used and shall be full bore with smooth interior surfaces to eliminate obstruction and keep friction loss to a minimum.

7. Pumping equipment. Proper system design and installation shall assure that each grinder pump will be able to adequately discharge into the piping system during all normal flow situations including peak design flow. Combined static, friction and miscellaneous head losses during peak design flows for given paths of flow through the system shall be maintained below the recommended operating head of any unit on the given path. The equipment shall be designed and manufactured with materials appropriate to wastewater service and shall meet all applicable safety, fire and health requirements arising from its intended use in or near residential buildings. Inside installations must be examined for freedom from noise, odors and electrical hazards. Both free-standing and below-the-floor type installations are acceptable. Outside installations shall be provided with an access from the surface which is suitably graded to prevent the entrance of surface water and equipped with a vandal-proof cover for safety. Installation of nonsubmersible grinder/macerator pumps must be protected against entrance of surface water into the electrical portions of the equipment. This

Schedule JAM-5

may require that a motor breather be run from the interior of the motor and control compartment to a protected location higher than the maximum anticipated water or snow level. Waterproof factory-installed wiring and tamperproof access covers on wiring compartments are required.

A. The pumps shall have a head capability high enough to operate efficiently over the entire range of conditions anticipated in the system. Normally this will consist of a fixed static head component dependent on pump elevation with respect to the discharge point. The head capacity design point should be not more than eighty-five percent (85%) of the maximum attainable pressure. To insure proper operation, the units must be capable of operating under temporary loads above the normal recommended system design operating pressure without a serious reduction of flow or damage to the motor. The pump should be of flooded-suction design to assure that it will be positively primed. The pressure sewer system shall contain integral protection against back siphonage.

B. The grinder pumps shall operate at a noise level sufficiently low to be acceptable for installation inside a residential building. Generally this should be no louder than other motor-operated devices normally found in homes such as furnace blowers, sump pumps and similar equipment. The grinder pump equipment shall comply with National Electrical Code and applicable local building code requirements.

C. Both stable-curve centrifugal and progressing cavity semipositive displacement pumps may be used in pressure sewer systems. The stable-curve centrifugal, a pump having a maximum head at no flow, may be considered for its ability to compensate with reduced or zero delivery against excessive high pressures and the ability to deliver at a high rate during low flow situations in the system, thus enhancing scouring during low flow periods. The progressing cavity semipositive displacement pump may be considered for its relatively constant rate of delivery in situations in which this feature is considered necessary. The semipositive displacement pump has no significant increases in delivery against low-flow system conditions to enhance scour during minimum flow times.

D. The grinding pumping equipment must include an integral grinder capable of handling any reasonable quantity of foreign objects which customarily find their way into building drainage systems as a result of carelessness or accident on the part of building occupants. The particle size produced by the grinder must be small enough to insure that the processed solids will not clog the grinder, the pump or any part of the discharge piping system. The grinder pump must be capable of processing these foreign objects without jamming, stalling, overloading or undue noise. The grinder shall be of a configuration to provide a positive flow of solids into the grinding zone. Open shafts shall not be exposed in the raw waste passageways since this will cause wrapping of cloth, string etc. around the blades or shaft.

E. The pump tank must be made of corrosion-resistant materials which are suitable for contact with sewage and direct burial below grade without deterioration over the projected lifetime (at least twenty (20) years). The tank shall be of a fifty (50)-gallon minimum capacity and be able to accommodate normal peak flows without exceeding its peak flow capacity. The volume between the on and off levels in the tank should be based on a sensible compromise between excessive unit operation and efficient removal of raw sewage into the system. In areas in which the groundwater table is high, tanks should be securely anchored to avoid floating. The geometry of the tank bottom and the pump suction currents generated when the grinder pump is in operation must be adequate to scour solids from the bottom of the tank so that there is no significant long-term accumulation of settleable solids on the tank bottom. The tank shall be vented so that air space above the wastewater is always at atmospheric pressure. Separate vents shall be provided if required by local codes but normally the fill piping connected to the building drain system will provide adequate venting. The tank shall be capable of accommodating connection to all normal building drainage piping systems. This would include three (3) and four (4)-inch sizes of PVC, cast iron, copper, vitreous clay and asbestos-cement pipe. The pump tank shall be furnished with integral level controls which reliably turn the pump on and off at appropriate and predictable levels. The level control shall be as trouble-free as possible with little care required for proper calibration. Mercury control, float type or pressure-type switches are acceptable. An alarm unit, visible or audible, shall be provided to indicate pump failure.

8. Power outages. Provisions must be made for periods of power failure. Alternatives are as follows:

A. Depend upon built-in storage of tank and associated gravity piping;

B. Provide additional storage capacity where power outages occur frequently (twenty-four (24)-hour storage capacity is recommended); or

C. Provide a mobile generator or pump to connect to each household for a short term during an extended outage.

9. Service. A twenty-four (24)-hour repair time either by replacement or repair must be assured. Spare grinder pump units should be stocked according to the following:

Installations	Spare Unit(s)
1—10	1
10—20	2
20—40	3
40—60	4
60—100	5
100—200	6
over 200	3% of installations

10. Instruction manuals. The equipment must be furnished complete with detailed wiring diagrams, suggested piping installations and detailed instructions for use by the contractor at the time of installation.

11. Construction factors. Granular bedding should be provided at least four inches (4") deep but not less than one (1) pipe diameter. The bedding should be smoothed prior to pipe installation. The excavation should be backfilled to a depth of eighteen inches (18") above the pipe with select backfill material. The bedding shall contain no rock greater than one inch (1") in diameter. Native materials may be used for the remainder of the backfill. Thrust blocks must be placed on all lines two inches (2") and larger at intersections and changes of direction of forty-five degrees (45°) or more.

12. Termination of force mains. Force mains and pressure trunks shall terminate in manholes using the following construction procedures:

A. The discharge shall be to the bottom of the manhole in line with the flow if possible;

B. Where piping must be installed to bring the discharge to the bottom of the manhole, the pipe shall be adequately braced to prevent movement, shall be vented on the top and shall allow access to the force main for cleaning purposes; and

C. Consideration shall be given for the possible need for odor control facilities at the termination of force mains and pressure sewer trunks.

13. Testing. Pressure tests shall be made only after the completion of backfilling operations and after the concrete thrust blocks have set for at least thirty-six (36) hours.

A. The duration of pressure tests shall be a minimum of one (1) hour unless otherwise directed by the engineer. Test pressure shall be fifty pounds per square inch (50 lbs. psi) minimum with a recommended pressure of two and one-half (2 1/2) times the maximum system operating pressure. All tests are to be conducted under the supervision of the engineer.

B. The pipe line shall be slowly filled with water. The specified pressure measured at the lowest point of elevation shall be applied by means of a pump connected to the pipe in a manner satisfactory to the engineer.

C. During filling of the pipe and before applying the specified pressure, all air shall be expelled from the pipeline by making taps at the point of highest elevation. After completion of the test the taps shall be tightly plugged at the main.

14. Septic tank effluent pump (STEP) systems. Septic tank effluent pump pressure sewer systems may be considered a similar application of the pressure sewer principle and the criteria contained in this rule may be used for these systems. Deviations from the criteria in this section when designing STEP systems will be judged on a case-by-case basis using substantiating information and material submitted with the design by the consulting engineer.

(10) Sewage Pumping Stations. Pumping stations serving subdivisions or other properties which might become incorporated into an existing or proposed comprehensive sewerage system at some future date shall be designed and constructed in accordance with 10 CSR 20-8.130 Sewage Pumping Stations.

(A) General. Every effort should be made to eliminate the necessity of pumping sewage in installations of the type covered in this rule.

1. Location. Sewage pumping stations should be located above the twenty-five (25)-year flood level and shall be readily accessible for maintenance. As a minimum, an unobstructed all-weather access road should be provided to the pump station.

2. Water supply protection. There shall be no physical interconnection between any potable water supply and a sewage pumping station or any of its components which under any conditions might cause contamination of a potable water supply. Sewage pumping stations shall be located at least one hundred feet (100') and preferably three hundred feet (300') from any potable water supply well.

3. Duplicate pumps required. At least two (2) pumps or pneumatic ejectors shall be provided. Each pump shall be capable of handling the design and maximum flows so that each unit is a duplicate of the other. The pump installation shall be designed to handle as a maximum flow four (4) times the average daily flow. Single pump installations may be given consideration only for very small installations, where average daily flows are less than fifteen hundred (1500) gallons per day, and only if the station is designed to permit the installation of a future duplicate unit without structural change and satisfactory means are provided to detect malfunctions and take corrective actions before an overflow to waters of the state could occur.

(B) Design Considerations. All pumps except suction-lift types shall be placed so that under normal operating conditions they will operate under a positive suction head. Design of the sewage pumping stations shall consider the following:

1. Types of pumps. Sewage pumping units may be categorized as follows: submersible pumps, pneumatic ejectors, vertical pumps and suction-lift pumps.

A. Submersible pumps shall be readily removable and replaceable without dewatering the wet well and with continuity of operation of the other unit(s) maintained. Both standard and cutter/grinder pumps are acceptable. Submersible pump installations shall be equipped with check and shutoff valves on each discharge line located in a box outside of the wet well.

B. Pneumatic ejector station structures constructed of metal shall be coated with an acceptable corrosion-resistant material and shall be supplied with two (2) properly sized anodes for cathodic protection to be buried on opposite sides of the structure and securely connected to the structure by heavy copper or aluminum wire. The air storage chamber and sewage receiving chamber (wet well) shall be capable of withstanding one hundred fifty percent (150%) of the design working pressure.

C. Suction-lift pumps shall be of the self-priming type as demonstrated by a reliable record of satisfactory operation. The total suction lift should not exceed fifteen feet (15');

2. Pump openings. Pumps shall be capable of passing a two and one-half inch (2 1/2") sphere when pumping raw sewage. These pumps shall have suction and discharge openings of at least three inches (3") in diameter. Pumps handling settled sewage need not necessarily meet these requirements depending upon the outflow design from the settling device. If cutter/grinder pumps are used, the previously mentioned requirements may be modified;

3. Accessibility. Adequate openings and facilities to permit maintenance, cleaning and removal of pumps and equipment shall be provided;

4. Protection of motors. Pump motors shall be so located to prevent damage by flooding or corrosion or otherwise satisfactorily protected from this damage;

5. Ventilation. Adequate ventilation shall be provided in all pump stations. Where the pump pit is below the ground surface, mechanical ventilation providing at least twelve (12) complete air changes per hour shall be provided. Portable ventilation equipment should be available when entrance to the wet well is required;

6. Wet wells. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting and to avoid septic conditions due to excessive detention time. The floor of the wet well shall have a minimum slope of one to one (1:1) to a hopper bottom. The horizontal area of the hopper bottom shall not be greater than necessary for proper installation and function of the inlet. The high water level in the wet well during normal operation shall be at least one foot (1') below the invert of the incoming sewer;

7. Controls. Control float bulbs, tubes, wires etc. should be located as not to be unduly affected by flows entering the wet well or by the turbulence created by the suction of the pumps. In stations with duplicate units, provision of automatic alternation of pump use shall be provided. Electrical equipment in enclosed places where hazardous gases may accumulate shall comply with the National Electrical Code for Class I Group D Division 1 locations;

8. Valves. Suitable shut-off valves shall be placed on the suction line of each pump except on submersible or suction-lift pumps. Suitable shut-off and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shut-off valve and the pump. Check valves shall not be placed on the vertical portion of discharge piping. No valves may be located in the wet well;

9. Overflows. Sewage pumping stations shall be designed to prevent bypassing of raw sewage to waters of the state and to prevent backups of sewage into buildings or property served by the sewerage system. A satisfactory method shall be provided to prevent or treat overflows. If a less preferred method is proposed, justification shall be provided for its choice. The following examples of some of the methods which will be considered are listed in order of their preference:

A. A holding basin with capacity for twenty-four (24)-hour retention of peak flows unless data justifies the use of a smaller

Schedule JAM-5

basin. The basin must be designed to drain back into the wet well or collection system as the influent flow recedes;

B. A portable pump capable of being connected to the pumping station or a portable generator; or

C. Storage of excess flow in trunk line sewers provided sufficient capacity for twenty-four (24)-hour storage of peak flows is available and flooding of basements will not occur; and

10. Alarm systems. Alarm systems shall be provided for all pumping stations. The alarm shall be activated in cases of power failure, pump failure or any cause of high water in the wet well. If possible, the alarm should be telemetered to a location that is manned twenty-four (24) hours per day. Audio-visual alarms with self-contained power supply shall be provided as a minimum. A sign shall be posted at each pump station in a clearly visible location, listing a telephone number to be called if the alarm is seen or heard; and

11. Instructions and equipment. Sewage pumping stations and their operators should be supplied with a complete set of operational instructions including emergency procedures, maintenance schedules, tools and spare parts as may be necessary.

(C) Force Mains. Design considerations for force mains are as follows:

1. Velocity. At design average flow, a cleansing velocity of at least two feet (2') per second shall be maintained;

2. Size. In general, three-inch (3") diameter pipe shall be the smallest used for raw sewage force mains. However, use of grinder pumps or similar equipment may allow use of smaller pipe. These instances will be reviewed on an individual basis. Piping materials may be pressure pipe normally used for conveying potable water, however the effects of surges and pressures within the system should be considered in the selection of the piping material. As a minimum SDR 21 PVC pressure pipe or its equivalent should be used. The force main and fittings including reaction blocking shall be designed to withstand normal pressure and pressure surges (water hammer);

3. Air relief valves. An automatic air relief valve shall be placed at high points in the force main to prevent air locking. However, consideration will be given to alternate proposals with proper substantiation;

4. Termination. Force mains should enter the gravity sewer system at a point no more than two feet (2') above the flow line of the receiving manhole; and

5. Water line and sewage force main separation. There shall be at least a ten-foot (10') horizontal separation between water lines and sewage force mains. There shall be an eighteen-inch (18") vertical separation at crossings as required in paragraph (9)(A)4. of this rule. Only in extenuating circumstances will deviations be allowed to these minimum separation distances.

(11) Small Wastewater Treatment Works. Treatment the extent of which will depend on 10 CSR 20-7.015 Effluent Regulations and 10 CSR 20-7.031 Water Quality Standards shall be provided in connection with all installations. Secondary treatment shall be the minimum acceptable degree of treatment. Wastewater treatment plants should be designed to provide for the estimated population and flows to be fifteen (15) or twenty (20) years hence. The following items shall be taken into consideration in planning sewage treatment works:

(A) Plant Location. In general to avoid local objections, the wastewater treatment facilities should be located as far as is practical from any present built-up area or any area which will develop within a reasonable future period. No sewage treatment facility shall be located closer than fifty feet (50') to any dwelling or establishment.

1. The treatment facility shall be located above the twenty-five (25)-year flood level.

2. An all-weather access road shall be provided from a public right-of-way to every treatment facility. Sufficient room shall be provided at the site to permit turning vehicles around. In determining the type of roadway and method of construction, consideration shall be given to the types of vehicles and equipment necessary to maintain and operate the facility. If access is required for heavy sludge trucks, the road must be of more substantial construction than one (1) used only for access of mowing equipment or other light vehicles. Gravel roads to be used by heavy vehicles shall have a minimum depth of six inches (6") of crushed rock material with a bottom layer of four inches (4") of two to three inch (2–3") size material and a top layer two inches (2") thick of three-fourths inch (3/4") size material. In general, the grade of the access road shall not exceed twelve percent (12%).

3. Wastewater treatment facilities shall not be located within one hundred feet (100'), and preferably three hundred feet (300') of any well or water supply structure;

(B) Design.

1. Type of treatment. Careful consideration should be given to the type of treatment before making a final decision. A few of the important factors to consider are the location and topography of the plant site; character and quantity of the wastes to be treated; operating costs and the probable type of supervision and maintenance the plant will receive. Particular care must be used in choosing methods of treatment for seasonal use developments, such as parks and campgrounds, and for developments which produce waste loads which fluctuate between wide extremes from day-to-day. The use of activated sludge type plants is generally not recommended for these developments because a high degree of operating efficiency for these plants is dependent in part upon a relatively stable loading condition. Where all use of the development is confined to a specific season, consideration should be given to designing lagoon systems on the draw-and-fill concept, retaining all wastewaters generated during the season of use and discharging them after an appropriate period during the off season or utilizing the stored water for irrigation.

2. New processes, methods and equipment. The policy of the department is to encourage rather than obstruct the development of new methods and equipment for the treatment of sewage wastes. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The department may approve other types of wastewater treatment processes or equipment under the following conditions:

A. The operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably sized prototype unit operating at its design load conditions to the extent required by the department; and

B. The department may require test results and engineering evaluations demonstrating the efficiency of the processes or equipment. The department may also require that appropriate testing be conducted and evaluations, other than those employed by the manufacturer or developer, be made under the supervision of a competent process engineer.

3. Sewage flow and strength. Minimum design loadings for all treatment processes shall be calculated using the following table unless the engineer can document the validity of lower per capita figures based on actual waste strength and/or flow data from the development to be served or from similar developments.

Table I

Type of Establishment	Pounds BOD per person (unless otherwise noted)	Gallons per day per person*
Employee Sanitary Waste	.05	15

Generally means eight (8)-hour shift employees at institutions, commercial establishments, factories and similar establishments. Total employee waste figure, if applicable, must be added to the appropriate patron or residential total from the following table:

Residential

Single family dwellings	.17	75–100
Apartments or condominiums	.17	60–100
Rooming houses	.15	45
Boarding houses	.17	75
Mobile homes	.17	75–100

Food or Drink Establishments (wastes per patron)

Tavern or bar (not serving food)	.01	2
Fast-food (paper service)	.02	3
Cafe or restaurant	.03	5
Restaurant serving alcoholic beverages	.04	5
Restaurant grinding garbage	.07	6

Schools (wastes per student)

Day school, no cafeteria, gym or showers	.02	10
With cafeteria—ADD	.02	4
With garbage grinding—ADD	.02	1
With gym and showers—ADD	.01	10
Boarding schools	.17	75

Institutions

Hospitals (per bed)	.22	125–200
Institutions other than hospitals	.17	100–150
Nursing homes	.17	100–125

Commercial and Recreational

Public parks (toilets only)	.02	5
Public parks with bath house, showers, toilets	.06	15–25
Swimming pools and beaches	.06	15–25
Country clubs (per resident member)	.17	75–100
Country clubs (per member present)	.06	15–25
Service stations (wastes per customer)	.01	5
Laundromats (per machine)	1.25	580
Hotels	.15	50
Motels (without restaurants)	.10	40
Luxury resorts	.17	75
Camper trailers	.08	30
Work or construction camps	.15	60
Churches (per seat)	.01	5
Stores, malls or shopping centers (per one thousand (1000) square feet of floor area)	.34	200
Stadiums, auditoriums, theaters or drive-in (per seat)	.01	5

*Note: Gallons per person per day includes normal infiltration for residential systems.

4. Population to be served. Unless satisfactory justification can be given for using lower per-unit occupancies, the following numbers shall be used in determining the population for which to design the sewage works:

	Persons/ Unit
Residences	3.7
Apartments or condominiums	
(1 bedroom)	2.0
(2 bedroom)	3.0
(3 bedroom)	3.7
Mobile homes	3.0–3.7
Camper trailers without sewer hookup	2.5
Camper trailers with sewer hookup	3.0
Motels	3.0

5. Organic loading. Where sewage strengths are expected to be materially greater than normal domestic sewage (three hundred milligrams per liter (300 mg/l) biochemical oxygen demand), consideration shall be given to enlarging settling, digestion and secondary treatment units.

6. Conduits. All piping and channels should be designed to carry the maximum expected flows. The incoming sewer should be designed for free discharge. Pockets, corners and channels where solids can accumulate should be eliminated. Suitable gates should be placed in channels to seal off unused sections which might accumulate solids. Shear gates or stop-planks should be used in preference to gate valves or sluice gates.

7. Arrangement of units. Component parts of the facility should be arranged for greatest operating convenience, flexibility, economy and so as to facilitate installation of future units.

(C) Facility Details.

1. Mechanical equipment. Mechanical equipment shall be used and installed in accordance with manufacturers' recommendations and specifications. Major mechanical units should be installed under the supervision of the manufacturers' representative.

2. Emergency operation. Facilities which enable removal of treatment units from service for cleaning, maintenance or mechanical breakdown without bypassing must be provided.

3. Drains. Means should be provided to dewater each unit. Pumping with portable pumps into a holding basin or other suitable disposal site will be considered a satisfactory means of dewatering. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures.

4. Construction materials. Due consideration should be given to the use of construction materials which are resistant to the action of hydrogen sulfide and other corrosive gases, greases, oils and similar constituents frequently present in sewage.

5. Operating equipment. Specifications should include a complete outfit of tools necessary for proper maintenance of the facility. If required by the department, an operation and maintenance manual shall be provided to explain the operating procedures at a level easily understood by the owner or operator of the facility. The manual, at a minimum, shall address maintenance of mechanical equipment, monitoring, record keeping and operating procedures including the amount, frequency and method of sludge disposal.

6. Grading and landscaping. Upon completion of the facility, the ground should be graded to prevent erosion and the entrance of surface water into any unit.

7. Treatment facilities outfalls. The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the department. In general the effluent from the final treatment process shall be conveyed to a defined stream channel via a closed pipe or a paved or rip-rapped open channel. Sheet or meandering drainage is not acceptable. The outfall sewer shall be so constructed and protected against the effects of floodwater, ice or other hazards as to reasonably insure its structural stability and freedom from stoppage. All outfalls shall be designed so that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

8. Potable water supply protection. No piping or other connections shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply. Potable water from a municipal or other supply may be used above grade for water closet, lavatory, drinking fountain or similar fixtures. A reduced pressure backflow preventer or break tank shall be used to isolate the potable system from all plant uses other than the ones provided for in this rule. Where a break tank is used, water shall be discharged to the break tank through an air-gap at least six inches (6") above the maximum flood line, ground level or the spill line of the tank, whichever is higher. Backflow preventers shall be located above the maximum flood line or ground level. A sign shall be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank or backflow preventer to indicate that the water is not safe for drinking. Where a separate non-potable water system is to be provided, backflow prevention will not be necessary but all system outlets shall be posted with a permanent sign indicating that the water is not safe for drinking.

9. Sewage flow measurement. Flow measurement shall be provided for all wastewater treatment facilities. Flow measurement should not be less than pump calibration time clocks or calibrated flume or weir and stilling basins as required.

10. Protection from the elements. All sewage treatment facilities except those which operate only seasonally shall be designed to assure effective operation under all weather conditions. Protection from the elements must be given special consideration since small wastewater treatment facilities will frequently be located in remote areas and may not receive daily attention. Freezing temperatures affect most treatment facilities to some degree. Open sand filters and small extended aeration plants are likely to be affected the most. Provisions for covering exposed process areas with boards or insulating panels may be sufficient in many cases. The use of heat tapes around sludge and scum return piping may be helpful in addition to covering the tanks. Sufficient electrical outlets should be provided at the plant site for this purpose. Tanks which are not completely backfilled on all sides may require additional protective measures during freezing weather. Any such measures taken to comply with these provisions shall not present a hazard to the operator nor hinder the operation of the treatment facility.

11. Safety. Adequate provisions should be made to protect the operator and any visitors from unnecessary hazards.

A. All wastewater treatment facilities must be fenced sufficiently to restrict entry by children, livestock and unauthorized persons as well as to protect the facility from vandalism.

B. Fences shall be a minimum of five feet (5') in height and shall be constructed of durable materials appropriate to the site and nature of the treatment facilities. Posts shall be imbedded to a sufficient depth or otherwise securely anchored to prevent displacement and shall not be spaced more than twenty feet (20') apart. Barbed wire, woven wire fabric or chain link mesh shall be securely fastened to the posts with fasteners designed for the type of material used.

C. Fences shall be located far enough back from all process units to permit easy access for operation and maintenance and for access of mowing equipment, sludge trucks and similar equipment. A minimum four foot (4') clearance from all units is recommended.

D. Woven wire fabric will generally be acceptable for fencing lagoons and other small facilities having a minimum of mechanical equipment. The fabric should nearly touch the ground surface and should have small enough mesh in the lower two feet (2') to prevent passage of small animals. Larger and more complex treatment facilities should be provided with chain link or similar fencing.

E. At least two (2) strands of barbed wire shall be provided above the fence fabric spaced no more than six inches (6") apart.

F. At least one (1) gate shall be provided for access of maintenance equipment and vehicles and each gate shall be provided with a lock. Gates shall be constructed in a manner and of materials comparable to those used for the fence. Gates shall be designed to prohibit entry of the enclosure by crawling underneath. When sizing the gate, consideration must be given to the need for entry of mowing equipment, sludge trucks or other vehicles or equipment necessary for routine maintenance and operation.

G. At least one (1) warning sign shall be placed on each side of the facility enclosure in such positions as to be clearly visible from all directions of approach. A sign shall be placed on each gate. Minimum wording shall be SEWAGE TREATMENT FACILITY—KEEP OUT. Signs shall be made of durable materials with characters at least two inches (2") high and shall be securely fastened to the fence, equipment or other suitable locations.

(12) Primary Treatment. For general requirements applicable to all types of treatment facilities, refer to section (11) of this rule.

(A) Grease Traps. Grease traps shall be provided on kitchen drain lines from institutions, hotels, restaurants, school lunch rooms and other establishments from which relatively large amounts of grease may be discharged to the treatment facility.

1. Grease traps should be located as close to the fixtures being served as possible and should receive only the waste streams from grease-producing fixtures. Sanitary waste streams, garbage grinder waste streams and other waste streams which do not include grease should be excluded from passing through the grease traps. Grease traps must be cleaned on a regular basis and must be readily accessible for this purpose.

2. Sizing of grease traps is based on wastewater flow and can be calculated from the number and kind of sinks and fixtures discharging to the trap. In addition, a grease trap should be rated on its grease retention capacity, which is the amount of grease (in pounds) that the trap can hold before its average efficiency drops below ninety percent (90%). Current practice is that grease-retention capacity in pounds should equal at least twice the flow capacity in gallons per minute. The following two (2) equations may be used to determine the capacity of grease traps for restaurants and other types of commercial facilities:

A. Restaurants.

$$D \times Gl \times Sc \times \frac{Hr}{2} \times Lf = \text{Size of grease trap in gallons, where:}$$

D = Number of seats in dining area;
Gl = Gallons of wastewater per meal, normally 5 gallons;
Sc = Storage capacity factor, minimum of 1.7;
Hr = Number of hours open; and
Lf = Loading factor,
1.25 interstate highways
1.0 other freeways
1.0 recreational areas
0.8 main highways
0.5 other highways.

B. Hospitals, nursing homes, other type commercial kitchens with varied seating capacity.

$$M \times Gl \times Sc \times 2.5 \times Lf = \text{Size of grease trap in gallons, where:}$$

M = Meals per day;
Gl = Gallons of wastewater per meal, normally 4.5;
Sc = Storage capacity factor, minimum of 1.7; and

Lf = Loading factor,
1.25 garbage disposal and dishwashing
1.0 without garbage disposal
0.75 without dishwashing
0.5 without dishwashing and garbage disposal.

3. Grease traps shall be provided with a manhole or opening of sufficient size to permit inspection and cleaning. When the grease trap is located below ground, the access opening shall be extended to grade. The opening shall be fitted with a tight fitting cover which will prevent the entrance of insects and vermin.

4. The grease trap should be constructed of materials similar to septic tanks and be properly baffled on both the inlet and outlet.

(B) Bar Screens. Bar screens should be provided before pumps, shredders or other mechanical equipment. Bar screens should precede imhoff tanks, primary settling basins and extended aeration plants.

1. Bar screens should be located to provide for easy cleaning and adequate drainage of screenings. Design must provide for removal and/or cleaning of bar screens or debris baskets located inside pump station wet wells without entering the wet well.

2. The invert of a bar screen channel or the bottom of a debris basket shall be a minimum of six inches (6") below the invert of the incoming sewer and a minimum of six inches (6") above the highest liquid level in the pump pit or treatment process tank. The channel preceding and following the screen should be filleted to prevent stranding and sedimentation of solids.

3. Clear openings between bars of hand cleaned screens should be from three-fourths to one and one-half inches (3/4–1 1/2"). Construction should be such that the screens can be conveniently raked.

4. The area of the screen openings should be sufficient to provide a velocity of one foot (1') per second through the vertical projection of the screen openings at average flow.

5. Hand cleaned screens should be placed on a slope of thirty to forty degrees (30–40°) with the horizontal.

6. Ample facilities must be provided for the removal, draining and deposit of screenings. Suitable storage facilities shall be provided where temporary storage of screenings is necessary. Screenings may be disposed of in an approved solid waste disposal facility.

(C) Septic Tanks. Septic tanks may be accepted as a satisfactory means of primary treatment for installations receiving flows not in excess of twenty-two thousand five hundred (22,500) gallons per day. Minimum acceptable liquid capacity for septic tanks shall be seven hundred fifty (750) gallons. Septic tanks should be designed and constructed in accordance with 10 CSR 20-8.021(4).

(D) Comminutors. Comminutors may be used in conjunction with bar screens as a means of preliminary treatment upstream of extended aeration plants. A screened bypass channel to a bar screen shall be provided. The use of the bypass channel shall be automatic at depths of flow exceeding the design capacity for the comminutor. Each comminutor that is not preceded by grit removal equipment should be protected by a six-inch (6") deep gravel trap. Provisions shall be made to facilitate servicing units in place and removing units from their location for servicing. Electrical equipment in comminutor chambers where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class 1, Group D, Division 1 location). Grinder pumps may be used in lieu of comminutors. Grinder pumps used for preliminary treatment must be sized to pump the maximum flow unless they are being used as part of flow equalization.

(13) Secondary Treatment. Criteria for design of secondary treatment processes are given for the most commonly used and recognized waste treatment processes applicable for small sewage treatment facilities. They include waste stabilization and aerated ponds, sand filters, extended aeration activated sludge and disinfection. Unit processes not covered by these criteria will be reviewed in accordance with paragraph (11)(B)2. The effluent quality that may be expected from a secondary treatment unit process or combination of processes is related not only to the engineering design but, most important, to the level of operation and maintenance that the units receive. The design criteria established in the rule for the various units are to reflect those features considered necessary for the unit to perform at its best efficiency, to ensure ease in operation and maintenance and to guide designers in selecting materials which will ensure the completed project will be durable. For other requirements applicable to all types of treatment facilities, refer to section (11).

(A) Wastewater Stabilization Ponds. Waste stabilization ponds provide treatment of primarily domestic wastewater by the unaided natural processes of biological activity. The wastewater stabilization pond process requires the least operational and maintenance skill of all processes considered in this rule. The criteria contained in this rule is for facultative and aerated facultative ponds.

1. The summary of design data shall include pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required by sections (4) and (7):

A. A layout showing the direction and distance of all cultural features within one fourth (1/4) mile of the proposed site. A seven and one-half (7.5) minute quadrangle map made by the United States Geological Survey of the area under consideration is acceptable, provided the map is field checked for accuracy in depicting present cultural features;

B. A geological evaluation of the proposed pond site prepared by the Missouri Department of Natural Resources, Division of Geology and Land Survey shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the appropriate department office:

(I) A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

(II) Size of the pond and/or approximate volume of waste to be treated;

(III) Maximum cuts to be made in the construction of the pond; and

(IV) Location and depth of cut for borrow area, if any;

C. A determination as to the compatibility of the proposed site with local zoning ordinances.

D. A description, including maps, showing elevations and contours of the site and adjacent area shall be provided;

E. Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion;

F. Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible. The four-foot (4') separation distance does not necessarily apply to perched water tables due to impervious strata near the surface;

G. Proximity of ponds to water supplies located in areas of porous soils and fissured rock formation shall be evaluated to

Schedule JAM-5

avoid creation of health hazards or other undesirable conditions; and

H. In general, to avoid local objections, the wastewater stabilization pond should be located as far as is practical from any existing built-up areas or existing dwellings. In no case should the pond be located closer than two hundred feet (200') from an existing built-up area or existing dwelling. The pond should be located at least one hundred feet (100') from the building(s) that it serves.

2. Basis for design. A flow-through stabilization pond shall be considered capable of meeting effluent limitations of forty-five (45) mg/l BOD and seventy (70) mg/l suspended solids. Controlled discharge stabilization ponds shall be considered capable of producing an effluent of a quality that is much better than a flow-through stabilization pond when treating normal domestic type sewage.

A. In general, waste stabilization ponds shall be designed on the basis of thirty-four pounds (34 lbs) of applied BOD per day per acre of water surface area in the primary cell. Water surface area shall be computed as area at the three foot (3') operating level. A minimum of one hundred twenty (120) days' detention time should be provided in the total system. To achieve this detention time the use of secondary cells up to five feet (5') deep and the use of third cells up to eight feet (8') deep may be necessary.

B. For aerated wastewater stabilization ponds, the development of final design parameters, it is recommended that actual experimental data be developed. However, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3\, k_1 \times (100 - E)}$$

where
t = detention time in the aeration cell in days;
E = percent of BOD_5 to be removed in an aerated pond; and
k1 = reaction coefficient aerated pond, base 10.

For normal domestic sewage, the k_1 value may be assumed to be 0.12 at a temperature of twenty degrees Centigrade (20 °C) and 0.06 at a temperature of one degree Centigrade (1 °C). A temperature of one degree Centigrade (1 °C) must be used for determining the detention time. Other k_1 values may be used to determine detention time when pilot test data is obtained by incubating anticipated wastes at critical operating temperatures. A temperature of twenty degrees Centigrade (20 °C) may be used for determining aeration requirements. As a minimum, aerated facultative pond systems designed to treat a typical domestic waste (BOD ≤ 300 milligrams per liter) shall consist of one (1) or more aerated cells and one (1) quiescent cell which provide the following minimum hydraulic detention times:

Minimum Detention Times for Aerated Pond Cells for Typical Domestic Waste (BOD ≤ 300 mg/l)

*No. of Aerated Cells	Days** for Treatment	Quiescent Cell, Days	Total Detention*** Time, Days
1	44	2–10	46–54
2	26	2–10	28–36
3	21	2–10	23–31

*For multiple aerated cells, the first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume.

**Includes three (3) days' detention time for sludge accumulation. Sludge volume is based upon 1.54 days detention time per one hundred milligrams per liter (100 mg/l) of suspended solids in the influent for a twenty (20)-year accumulation of sludge.

***Total detention time for all cells combined.

(I) The design minimum detention time of aerated cells treating domestic type waste of greater strength than three hundred (300) mg/l BOD should be determined utilizing the equation from subparagraph (13)(A)2.B. on a per-cell basis. For aerated facultative pond systems designed to treat greater strength waste with a BOD of four hundred (400) mg/l or more shall consist of two (2) or more aerated cells and one (1) quiescent cell. The first two (2) cells shall be of equal size and no one (1) cell shall provide more than fifty percent (50%) of the total required volume. The following minimum detention times are presented for illustration and result from use of the formula from subparagraph (13)(A)2.B. with provision of additional volume for sludge accumulation.

Minimum Detention Times for Aerated Pond Cells for Greater Strength Waste

Influent BOD mg/l	No. of Aerated Cells	Days for Treatment	Quiescent Cell, Days	Total Detention* Time, Days
400	2	46	2–10	48–56
400	3	37	2–10	39–47
400	4	32	2–10	34–42
1000	2	87	2–10	89–97
1000	3	67	2–10	69–77
1000	4	58	2–10	60–68

*Total detention time for all cells combined.

C. Where any wastes discharged to a stabilization pond are from a restaurant, institutional kitchen or similar establishment likely to produce large amounts of grease, grease traps shall be provided as discussed in subsection (12)(A) of this rule. If ground garbage is also introduced to the waste stream from these sources, a septic tank having a capacity equal to at least five (5) times the average daily flow of that waste stream shall be provided for primary treatment preceding unaerated pond systems. Septic tanks sized at one and one-half (1.5) times the average may be provided as primary treatment for other waste streams. No reduction in BOD applied to the stabilization pond shall be allowed where the only pretreatment is grease removal. Where complete primary treatment is provided for any waste stream entering the pond system, the BOD loading of that stream may be reduced by thirty-five percent (35%) when determining the required pond system surface area or detention time.

D. Consideration shall be given to the type and effect of industrial wastes contributed to the stabilization pond system. For high strength wastes where the required detention time exceeds nine (9) months for an unaerated stabilization pond, consideration should be given to other processes such as aerated ponds, land application of the effluent or activated sludge treatment plants.

E. A minimum of three (3) cells in series shall be provided for all flow-through pond systems. The second cell shall be three tenths (.3) times the area of the primary cell and the third cell shall be one tenth (.1) times the area of the primary cell. For facultative pond systems where the primary cell will be smaller than ten thousand (10,000) square feet, consideration should be given to the use of land application of the effluent. See section (15) of this rule. If the use of land application methods is not feasible or would present a nuisance, and the primary cell size is between three thousand (3000) and ten thousand (10,000) square feet, the third cell of the series shall have an area of at least one thousand (1000) square feet. Where the primary cell is less than three thousand (3000) square feet, only a secondary cell of one thousand (1000) square feet area is required.

F. A minimum of three (3) cells is required for all controlled discharge pond systems. The first and second cells shall be sized as in subparagraph (13)(A)2.E. The third cell shall be a minimum of five tenths (.5) times the area of the primary cell. The third cell shall be placed at an elevation so that the primary and secondary cells may be lowered to the two-foot (2') operating level by gravity. Pumping from the secondary cell may be required to meet these criteria. Total detention time for the entire system shall be a minimum of one hundred sixty (160) days. Minimum storage above the two-foot (2') operating level in all the cells shall be one hundred (100) days.

G. Normal operating depths for flow through and controlled discharge pond systems shall be from two to five feet (2–5'). Depth in the third cell for flow-through and controlled discharge ponds shall be a minimum of five feet (5') but no greater than eight feet (8'). The minimum depth for aerated ponds shall be five feet (5'). Actual design depth for aerated ponds shall be based upon consideration of the type of aeration equipment used. Whenever possible each cell in a flow-through or aerated pond system should be designed with the water surface elevation at normal operating depth at least one foot (1') lower than the elevation in the preceding cell to facilitate independent variation of cell depths for maintenance and operational control procedures.

H. The shape of all pond cells should be such that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at the corners to minimize accumulations of floating materials. Common dike construction, wherever possible, is strongly encouraged.

3. Pond construction details.

A. The design and construction of pond dikes is to ensure a stable, water tight structure, that can be easily and safely maintained. The dikes must be constructed of impervious materials and compacted sufficiently to form a stable, water tight structure. The engineering plans and specifications must indicate the type of soils to be used in the construction, the methods of compaction that will be used and the quality control tests, if any, that are required. Compaction methods which would achieve a standard proctor density of ninety percent (90%) of optimum throughout the dike are acceptable.

B. The minimum dike width shall be four feet (4'). If large farm type equipment is to be used for mowing, a top width of eight feet (8') shall be provided. The top of the dike must be at least two feet (2') above the maximum depth of the cell.

C. Inner and outer dike slopes shall not be steeper than three to one (3:1). Inner slopes shall not be flatter than four to one (4:1). Consideration may be given to steeper inner slopes provided special attention is given to stabilizing the slope with rip-rap, concrete or other rigid materials. These stabilization methods shall be specified. The flatness of the outer slope is of no concern provided surface water can be diverted around the lagoon. Long outer slopes should be flatter than three to one (3:1) to assist in safe mowing of vegetation.

D. The area on which the dike rests shall be stripped of all organic matter and all tree roots grubbed. Selected organic material should be stockpiled and spread on the outer surface of the completed dike to assist in establishing vegetation. Trees and brush must be removed from the immediate construction site. As a general rule, all trees within one hundred feet (100') of the water's edge of the pond shall be removed. Special consideration will be given to leaving selected trees if—

(I) The trees' location will not result in shading of the pond's surface;

(II) Roots from trees will not imperil the dike structure;

(III) Felling of the tree from a storm or its natural death will not cause the tree to enter the pond; or

(IV) Leaf litter from the tree will not have an adverse effect on the pond's effluent.

E. The pond dikes shall be sufficiently smoothed to allow the passage of mowing equipment without scalping or danger to the operator from tipping. The completed surface shall have all rocks removed which might endanger the mower operator or equipment.

F. Diversion terraces and ditches are required to prevent surface water intrusion into the lagoon. Diversion ditches shall be designed to minimize erosion by incorporation of ditch blocks, paved inverts, rip-rap or sodding as necessary. Long slopes of diversion ditches shall be avoided whenever possible and when necessary shall be protected from excessive erosion by sodding, mulching and terracing techniques. Diversion terraces and paved outlets are recommended whenever runoff from areas adjacent to the diversion ditch will contribute sheet runoff down the ditch slope. Point runoff should be conveyed to the ditch by a paved outlet.

G. The dikes, diversion ditches and terraces shall be seeded and a good vegetative cover established to minimize erosion and aid in weed control. The inner dikes should be seeded down to the normal water line of the structure. Where the structure is not anticipated to reach its normal operating level during the first growing season, consideration should be given to further seeding on the dike slope. Long rooted grasses shall not be used for seeding of dikes. Fertilization needs, mulching and watering must be considered for all wastewater stabilization pond projects to ensure that a good growth of grass occurs rapidly and is sustained. Specifications shall detail specific amounts and variety of seeds to be used, mulching and fertilizer requirements as appropriate and the proper time period for application to be reasonably assured of success.

H. Rip-rap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s), design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

4. Pond bottoms.

A. Soil used in constructing the pond bottom (not including seal) and dike cores shall be relatively incompressible, tight and compacted at or up to four percent (4%) above the optimum water content to at least ninety percent (90%) standard proctor density. Any soil borings and tests to determine characteristics of surface soil and subsoil shall be made part of the summary of design data. The bottom should be cleared of vegetation and debris.

B. All ponds shall be sealed so that seepage loss through the seal is as low as possible. The pond seal shall cover the bottom and extend up the inner dike slope to where the side slope intersects with the top of the dike. Seals consisting of soils, asphalt, soil cement or synthetic liners may be used provided the permeability, durability and integrity of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil.

(I) The design permeability of the pond seal shall not exceed five hundred (500) gallons per acre per day in areas where potable groundwater might become contaminated or when the wastewater contains industrial contributions of concern. Design seepage rates up to thirty-five hundred (3500) gallons per acre per day may be considered in other areas where potable groundwater contamination is not a problem, provided that the pond cells will maintain adequate water levels to provide treatment and avoid nuisance conditions.

Schedule JAM-5

(II) Soils having a permeability coefficient of 10^{-7} centimeters per second or less with a compacted thickness of twelve inches (12") will be acceptable as a pond seal for water depths up to five feet (5') and for seepage losses less than five hundred (500) gallons per acre per day. For permeability coefficients greater than 10^{-7} centimeters per second (cm/sec) or for heads over five feet (5') such as an aerated pond system, the following equation shall be used to determine minimum seal thickness:

$$t = \frac{H \times K}{5.4 \times 10^{-7} \text{ cm/sec}}$$

where
K = the permeability coefficient of the soil in question;
H = the head of water in the pond; and
t = the thickness of the soil seal.
Units for H and t may be English or metric; however, they must be the same.

(III) Section (17) of this rule contains recommendations for seal design.

C. All ponds shall be prefilled to protect the liner, to prevent weed growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (13)(A)3.G. and H. of this rule before introduction of water.

D. If measurement of percolation losses is required by the department, the method of measurement shall be in accordance with section (16) of this rule. In no case shall measured percolation losses exceed thirty-five hundred (3500) gallons per acre per day. In areas where there is a significant potential for groundwater contamination, justification shall be provided before measured percolation losses will be allowed to exceed five hundred (500) gallons per acre per day and in no case shall percolation losses exceed seventeen hundred (1700) gallons per acre per day. Whenever industrial wastes are a significant part of the wastewater flow, the department may require more stringent seepage limitations and liner design considerations.

5. Influent lines.

A. An effort should be made to locate and orient the lagoon and tributary sewers so as to have only one (1) inlet. When multiple inlets are necessary, they shall be located to minimize possibilities of short circuiting and uneven loading of the pond. The inlet line to the primary cell of an unaerated pond system shall terminate at the two-thirds (2/3) point farthest from the outlet on the longest axis of the cell. The inlet line to an aerated pond cell shall discharge within the mixing zone of the aeration equipment.

B. Any type of piping generally used for transmitting sewage under pressure shall be used as the influent piping for a pond system. When plastic pipe or similar low density material is used, extra consideration must be given to anchoring or weighting the pipe to prevent flotation. Special consideration must also be given to the character of the waste, possibility of septicity, exceptionally heavy external loadings, abrasion, the necessity of reducing the number of joints, soft foundations and similar problems.

C. A manhole shall be installed prior to entrance of the influent line to the primary cell and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

D. Inlet lines should slope on a uniform grade and straight line beginning at the inlet manhole to a point approximately at the lagoon floor elevation. From this point, the pipe is laid flat to the point of discharge. The pipe may be laid flat on the lagoon bottom and anchored, or a trench of one (1) pipe diameter depth may be constructed with the fill material serving as the anchor. The inlet should discharge into a saucer-shaped depression with depth equal to six inches (6") or the inlet pipe diameter, whichever is greatest. The depression will have an area of approximately one-sixteenth (1/16) of the pond surface area. The inlet shall terminate over a concrete apron with a minimum size of three foot (3') square.

6. Transfer piping between cells and final effluent piping.

A. Minimum piping size shall be four inches (4") in diameter. Any pipe material suitable for transmitting sewage under pressure will be satisfactory provided the pipe is capable of withstanding heavy external loads from mowing equipment, and is resistant to chemical and biological deterioration. Cast iron, ductile iron or steel is recommended.

B. Control of water depth provides a number of benefits including better treatment efficiency during the different seasons, the ability to effectively operate the system on a partial draw- and fill-basis (phase isolation) and the natural control of mosquitoes, midge larvae and weeds. Minimum transfer pipe requirements in the primary cell shall be a single pipe, with gate valve placed to withdraw one-foot (1') below the pond water surface. Second and final cells and primary cells of controlled discharge ponds shall be provided with sufficient individual pipes and gate valves to raise and lower the pond levels in one-foot (1') increments from the two-foot (2') level upward. Final cells of flow through stabilization ponds in excess of five feet (5') deep shall level control piping in one foot (1') increments above five feet (5'). Final cells of controlled discharge ponds in excess of five feet (5') deep shall have level control piping in two-foot (2') increments above the two-foot (2') level. Overflow lines should discharge through anchored concrete structures at a point which will not cause dike erosion. Care shall be taken in location and design of transfer piping, valves and valve boxes to protect these appurtenances from damage by mowing equipment.

C. Transfer piping between aerated cells and from the quiescent cell shall consist of a single pipe equipped with a gate valve and located one foot (1') below the water surface.

D. The point of effluent draw-off from each cell shall be located as remotely as possible from the inlet to that cell.

7. Aeration requirements for aerated ponds.

A. Oxygen requirements generally will depend on the BOD loading, degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of two milligrams per liter (2 mg/l) in the pond at all times. Suitable protection from the weather shall be provided for electrical controls. The aeration equipment shall be capable of providing one and three-tenths pounds (1.3 lbs.) of oxygen per pound of BOD removed. BOD removal shall be based on warm weather rates. Appropriate manufacturer's data on aeration equipment oxygen transfer capability may be requested for review when this information is not available to the department.

B. Aeration equipment shall have sufficient power and shall be located to provide dispersion of oxygen throughout the aerated basin. For an aerated pond utilizing mechanical surface aerators, a minimum of ten (10) horsepower per million gallons of wastewater in the aeration basin shall be provided for mixing. In addition, aeration equipment and aeration basins shall be designed and installed to ensure that mixing patterns are adequate to prevent dead spots within the basin.

C. Shore-mounted diffused aeration systems shall be provided with duplex blowers and motors, with each blower capable of providing air requirements during the critical design condition. Floating surface aeration systems shall be provided with one

(1) spare motor, shaft and impeller of the size equal to the largest as those used in the design.

8. Outfall structures. Materials and design shall be in accordance with paragraph (13)(A)6. of this rule. (For additional requirements refer to paragraph (11)(C)7. of this rule.)

9. Fencing and signs. Fencing and signs for pond systems shall be in accordance with paragraph (11)(C)11. of this rule. In general for pond systems the fence shall be located at the outer toe of the dikes. Consideration may be given to other locations under specific circumstances. In all cases the fence must not be located where it can interfere with access to and mowing of the dikes.

(B) Activated Sludge Treatment Plants. For the range of flows covered by this rule, the extended aeration process is the most commonly used and criteria for this process follows. Criteria for the design of systems using other variations of the activated sludge process may be found in 10 CSR 20-8.180 Design of Sewage Works, Biological Treatment. The extended aeration plant is of the activated sludge type in which primary settling tanks are omitted, where prolonged aeration consumes some of the sludge and produces a relatively stable effluent and where the wasting of sludge is mandatory at varying intervals. The extended aeration process or any activated sludge process should not be considered where there is not at least five (5) days per week of wastewater flow into the plant. It should be noted that daily operation and maintenance attention by experienced plant personnel is absolutely necessary for proper operation. The engineer should carefully evaluate the ability of the owner to provide effective operation before making a recommendation to use the extended aeration process.

1. Location. Plants should be located close enough to the building being served to optimize maintenance of the plant. They should be located to be the least objectionable to actual or potential surrounding land use. A housed treatment plant component shall be located at least fifty feet (50') from any existing or future residence. Exposed treatment plant components, protected by only a fence or open grating, shall be located at least one hundred fifty feet (150') from existing or future residences. Distances to commercial buildings, industrial buildings, schools and similar structures must be evaluated with respect to type of structure being served and the actual use made of that part of the structure adjacent to the sewage treatment plant.

2. General. The side walls of all tanks which are open at the top shall extend at least six inches (6") above the adjacent ground surface with provision for erosion protection and drainage of the area surrounding the plant. All tanks shall have a minimum of ten inches (10") of freeboard above the maximum liquid operating level in each tank. Metal tanks shall be protected from corrosion by installation of anode packs. The location of the anode packs should be marked on the surface of the ground.

A. Riser sections may be used on plants where the invert of the influent sewer line has a maximum depth of four feet (4') below grade. Blower housing and electrical controls must be placed above the level of the riser section and above ground. All valve handles and cleanouts must be brought up to a minimum of one foot (1') from top of riser for easy maintenance. Where the invert of the influent sewer is deeper than four feet (4'), either a lift station should be provided and the plant be set at grade or a retaining wall or excavation with four feet (4') clear distance around the plant with free outfall of the drainage therefrom may be provided.

B. When phased development is proposed, one-half (1/2) the total ultimate capacity should be installed initially. Initial plans shall indicate all future phases of tributary development and ultimate plant capacity.

C. All treatment plant components shall be protected by one of the following methods:

(I) A rugged fence of chain-link, wood or block at least six feet (6') high with locked entrance gates. Plants located in areas where thrown objects or falling leaves might be a problem should be equipped with lightweight open grating over the tanks in addition to the fence described. Four foot (4') of working room must be provided around the plant;

(II) A building or housing constructed over the entire plant shall be provided with adequate means for gravity type ventilation by locating sufficient intake vents near the floor level and allowing the air to discharge out through large louvres or vents at ceiling height or by mechanical ventilation where gravity ventilation is not feasible. Housings over plants should provide at least seven feet (7') of headroom over the walkways. Adequate lighting shall be provided. Plants within buildings or housings shall be equipped with safe walkways providing access to all equipment and working areas housed therein. Access to the plant in a building should be by a door equipped with a lock. A minimum of four feet (4') of working room must be provided around the entire periphery of the plant;

D. The plant should always remain accessible. All-weather access roads are to be provided for all plants in accordance with paragraph (11)(A)2. of this rule; or

E. Plant equipment such as blowers, electrical controls and non-submersible pumps should be protected from foam and moisture. Equipment may be located either on top of the plant or in an adjacent enclosure. Guardrails with kickplates shall be provided at open tanks and along walkways, however, sturdy grating may be substituted over open tanks. Control valves shall be safely accessible from a position where firm footing is available. Motor shafts, pulleys, belts and the like shall be guarded. Above or below ground treatment units shall be accessible by sturdy stairways.

3. Pretreatment. Effective removal or exclusion of grit, debris, oil or grease and comminution or screening of solids shall be accomplished prior to the aeration tank. See section (12) of this rule for criteria applicable to preliminary and primary treatment devices. Stronger wastes from food service operations and wastes containing garbage or other organic matter increases both the hydraulic and BOD loadings and require special consideration. Excess organic materials, such as ground vegetables produced by supermarkets, should not be tributary to this type of plant. Garbage grinders should not be used in commercial facilities tributary to an extended aeration plant.

4. Flow equalization. Flow equalization facilities may be required for extended aeration treatment plants with flows greater than five thousand (5000) gallons per day. Equalization tanks must be located downstream of pretreatment facilities such as grease traps and bar screens.

A. A variety of methods may be employed to achieve flow equalization. Consideration may be given to on-line units, where all the flow passes through the equalization tanks and side-line units, where only that amount of flow above the maximum desired flow is diverted through the equalization tank(s). In addition, on-line treatment units may be utilized to dampen flow variations provided that the units are also capable of providing the required treatment efficiency throughout the entire range of operating wastewater depths.

B. Equalization tank size should be based upon a representative diurnal flow pattern derived from flow records or an acceptable approximation technique. The total equalization tank volume must be large enough to effectively reduce both flow and

Schedule JAM-5

load variations. Consideration should be given to dividing the flow equalization tank volume into two (2) compartments. The actual equalization tank volume must be greater than that obtained from the flow pattern in order to accommodate anticipated concentrated plant recycle streams such as supernatant from a digester or sand filter backwash. For new plants or where existing flows are not available to establish a representative diurnal flow pattern, Table I and the following criteria shall be used to approximate the required equalization tank volume.

C. Where existing flows are not available, the design peak flow factor shall be three and one-third (3 1/3) for all treatment plants. The peak daily flow for determining equalization tank volume shall be calculated as follows:

$$\text{Peak Daily Flow (gpd)} = \frac{3\ 1/3 \times \text{Average daily flow (gpd)} \times 24\ \text{(hrs.)}}{\text{Run-off period (hrs.)}}$$

Where the run-off period in hours is:

Subdivisions	16
Schools	8
Restaurants	12–16
Institutions	16
Commercial	12
Resorts	16
Motels	16

Table I

Recommended Flow Equalization Tank Volumes

As a Percent of the Average Daily Flow Q equ./Q avg.

Q max / Q avg.	1.0	1.5	2.0	2.5	3.0
1.0	0	-	-	-	-
1.5	13	-	-	-	-
2.0	22	8	-	-	-
2.5	29	16	5	-	-
3.0	33	22	12	4	-
3.5	37	27	17	9	3
4.0	40	30	22	14	8
5.0	44	36	29	22	16
6.0	48	41	34	28	22
7.0	50	44	38	32	27
8.0	52	46	41	36	31
9.0	53	48	44	39	35
10.0	55	50	46	41	37

NOTE: Q max = Design peak daily flow rate tributary to the equalization tank including all backwash. See paragraph (13)(B)4. of this rule.

Q avg. = 24-hour average design flow rate.
Q equ. = Desired equalized flow rate.

D. When pumps are utilized, duplicate pumps shall be provided. With air-lift pumps, this requirement may be fulfilled by a standby air supply.

E. Aeration or mechanical mixing must be provided to prevent deposition of solids in the tank(s) and to maintain aerobic conditions. Normal air requirement is two (2) cubic feet per minute per one thousand (1000) gallons of storage. The air supply shall be independent of plant process aeration facilities to ensure proper control.

F. Corner fillets shall be provided to facilitate the periodic removal of any accumulated sludge or grit.

G. Equalization tanks shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and ensure proper flow equalization. Devices to measure the equalized flow may also be required. The equalization tank shall be equipped with an overflow to ensure that all wastewater flow will pass through the secondary treatment facility before being discharged. The overflow shall be installed ten inches (10") above the normal maximum liquid level and shall interconnect the flow equalization tanks with the aeration chambers of the secondary treatment facility.

H. The equalization tanks should be designed to avoid varying pump rates with changing liquid levels in the tank. However, equalization tanks with varying outflow rates shall provide compensatory additional storage capacity.

5. Flow division. Flow division is required where parallel aeration unit arrangements are planned initially or as part of a future expansion. Proportionate distribution of incoming flow and return sludge shall be provided. The screening, comminuting device or bar screen must precede the flow division. Division of the total plant flow into more than two (2) parallel arrangements is generally unacceptable. If flow division is not accomplished in the equalization tanks, consideration should be given to pumping the flow into a diversion device to prevent deposition of solids where average flows are very low.

6. Aeration tanks. Aeration tanks shall be designed to allow for twenty-four (24) hours of detention time based on the expected twenty-four (24)-hour sewage flow of average strength, domestic sewage. For higher strength wastes, such as those from restaurants, the greater amount of BOD applied should be considered with the detention time increased. The design of tanks shall be based upon the following criteria:

A. The aeration tank shall be sized on the basis of an applied BOD load of fifteen pounds (15 lbs) per one thousand (1000) cubic feet of aeration tank capacity per day. The design BOD loading rate shall include all recycle streams except return activated sludge;

B. Shape and design of the tank should maintain an effective mixture and utilization of air and prevent deposition of solids or short circuiting;

C. Oxygen requirements generally depend on maximum diurnal organic loading, degree of treatment and level of suspended solids concentration to be maintained in the aeration tank mixed liquor. Aeration equipment shall be capable of maintaining a minimum of two (2) mg/l of dissolved oxygen in the mixed liquor at all times and providing thorough mixing of the mixed liquor. In the absence of experimentally determined values, the design oxygen requirement for the extended aeration process shall be one and eight-tenths pounds (1.8 lbs) of oxygen dissolved per pound of diurnal peak carbonaceous BOD. In the case of nitrification the oxygen requirement for oxidizing ammonia shall be four and one-half pounds (4.5 lbs) of dissolved oxygen per pound of ammonia;

D. Twenty-six hundred (2600) cubic feet of air per pound of applied BOD shall be provided for diffused air plants. Additional capacity must be provided for channels, air-lifts, aerobic digesters and other air use demands. Diffuser systems shall be capable of providing for the diurnal peak oxygen demand or two hundred percent (200%) of the design average oxygen demand, whichever is greater;

E. Blowers shall be provided in duplicate units, with each blower being capable of supplying all of the air requirements listed in this section. All installed blowers must be operable;

F. Easily removed drop-pipes with shut-off valves should be provided on each tank. A pressure gauge shall be provided on the outlet of each blower;

G. A maximum of four (4) tanks in series or a maximum of two (2) parallel arrangements of two (2) tanks each in series. In parallel arrangements, passports must be provided between tanks to prevent liquid build-up within any tank. Means for balancing air supply to each header must be provided. Means for varying the amount of return sludge, as well as the location of the return sludge discharge, must be provided. Separate blowers and piping plus standby blower(s) must be provided for parallel series arrangements; and

H. Time clocks will generally be approved only if the plant is operating at less than seventy-five percent (75%) of design load, will be operating with predictable variable loads or will be operating with light loading conditions which will significantly affect operations. Plants equipped with time clocks should be supervised by only trained, experienced personnel.

7. Final settling tanks. Final settling tanks following the aeration units shall be designed to give effective settling and continuous return of sludge. Detention time shall not be less than four (4) hours based on the average flow. Six to eight (6–8) hours may be required to handle peak flows. Design of the settling tanks shall be based on the following requirements:

A. The installation of multiple settling tanks in series is discouraged;

B. The area upstream of any part of the inlet baffle shall not be used in calculating the surface settling area. The maximum surface settling rate at peak rates of flow with flow equalization shall not exceed one thousand gallons (1000 gals.) per day per square foot for domestic type wastewater. For plants without flow equalization, the maximum surface settling rate shall not exceed one hundred fifty gallons (150 gals.) per day per square foot, at the twenty-four (24)-hour average design flow.

C. Tank hoppers should have a minimum side slope of sixty degrees (60°) to the horizontal and bottoms not in excess of one foot (1') square or one foot (1') in diameter. In computing detention capacity of nonmechanical hopper tanks, only the upper one third (1/3) (by height) of the hopper(s) may be included. Tank hoppers should be considered as commencing when two (2) or more sides have a side slope of sixty degrees (60°) to the horizontal. Dual hoppered tanks should provide a minimum water depth of two feet (2') over the junction of sixty degree (60°) walls between hoppers. The installation of more than two (2) hoppers per settling tank will not be accepted.

D. A baffle shall be provided at the inlet to prevent turbulence and short circuiting and to entrap grease and floatable materials (surface skimmer shall be downstream of this baffle). The inlet baffle shall extend across the width of the settling tank and shall extend continuously from a minimum of six inches (6") above normal water level to a minimum depth of two feet (2') below the inlet part to the settling tank. The inlet baffle shall be located no less than twelve inches (12") from the tank end wall nor more than twenty inches (20") to allow an effective collecting area for floatable materials without infringing on the clear surface settling area of the settling tank;

E. A baffle shall be provided at the outlet, within six inches (6") of the effluent trough and extending four to eight inches (4–8") below and six inches (6") above the liquid level;

F. The outlet from the settling tank shall consist of an overflow trough equipped with an adjustable plate weir. The weir length shall be at least twice the narrow dimension of the settling tank and the weir overflow rate shall in no case exceed twenty-five hundred gallons (2500 gals.) per day per lineal foot at the twenty-four (24)-hour design flow nor seventy-five hundred gallons (7500 gals.) per day per lineal foot at peak flow. The overflow trough should be located a sufficient distance from the end wall of the final tank to offset the effect of end wall currents;

G. Sludge withdrawal shall be based on a return rate of fifty to two hundred percent (50–200%) of the average daily flow with variable control of the return rate provided. Positive visible return should be provided. Each hopper shall have separate sludge withdrawal and transfer equipment. Piping and valving shall be at least six inches (6") above the liquid level. Sludge return airlifts shall be at least three inches (3") in diameter. Discharge piping should be at least four inches (4") in diameter and should be designed to maintain a velocity of not less than two feet (2') per second when operating at normal return rates. Suitable devices for observing, sampling and controlling return sludge flow from each settling tank hopper shall be provided;

H. Scum skimmers capable of continuously removing floating scum from the clarifier and returning it to the aeration zone shall be provided. The devices shall be easily adjustable. The design of air lift type scum removal devices must take into account the effect that the air lifts will have on the overflow rate in the settling tank. On food service operations, skimmers must discharge to a separate scum holding tank of no less than five percent (5%) of the food service daily hydraulic flow and be provided with a means of recirculating the subnatant to the aeration tank; and

I. Hosing facilities for routine flushing of walls and walkways at all facilities over five thousand gallons (5000 gals.) per day and at all food service operations shall be provided. Where water supply is not available, a pump with hose connection may be used. (See paragraph (11)(C)8. for requirement concerning potable water supply protection.)

8. Waste sludge facilities. An on-site sludge holding facility shall be provided at each extended aeration treatment plant designed under this rule. For normal domestic type wastewater, the holding tank shall have a minimum capacity of three (3) cubic feet per population equivalent served. For higher strength wastes, the basis for design shall consider that sixty-five hundredths pounds (0.65 lbs) of solids per day must be wasted for every pound of influent BOD removed per day. Solids concentration in the holding tank may average two percent (2%) and a minimum of forty-five (45) days' storage must be provided. Suitable piping and valves shall be provided to allow wasting of excess activated sludge from the plant to the holding tank. The holding tank shall be provided with aeration at a minimum rate of four (4) cubic feet per minute per one thousand (1000)-gallon capacity. A means of returning supernatant from the sludge holding tank to the inlet end of the plant aeration zone or flow equalization tank shall be provided. A positive means for decanting the supernatant must be provided as an overflow port is not acceptable. Since all plants must waste sludge, the summary of design data shall indicate where waste sludge will be disposed. Sludge should be hauled to a municipal wastewater treatment facility or other suitable sludge disposal facility. Typically a twenty thousand gallon (20,000 gal.)-per day plant may produce from seven hundred to one thousand gallons (700–1000 gals.) of concentrated waste sludge per week. Failure to provide for proper handling of waste sludge may lead to plant failure and evidence of sludge in the receiving stream. For the size of facilities covered by this rule, on-site sludge disposal is not recommended. If on-site sludge disposal is proposed, an engineer's report shall be submitted which addresses the requirements of 10 CSR 20-8.170.

9. Filtration of effluent. All activated sludge treatment facilities that are required to produce effluents with less than ten (10) mg/l BOD and fifteen (15) mg/l suspended solids or remove ninety-five percent (95%) or more of the influent BOD shall have filtration of the effluent in accordance with subsection (13)(C) of this rule. Filtration is recommended for all activated sludge plants that must remove ninety percent (90%) or more of the influent BOD. These plants must be designed so that filtration, if required at a later date, can be added.

(C) Sand Filters. Sand filters are generally considered suitable for treatment of small flows or for flows which are highly intermittent or seasonal. Sand filters are considered capable of producing an effluent that meets advanced secondary treatment requirements. Sand filters may be used following a septic tank or activated sludge treatment facility.

Schedule JAM-5

The possibility of intermittent objectionable odors occurring during dosing of open filters should be considered when locating these systems. The criteria contained in this section is for buried, open and high rate backwashed type sand filters.

1. Location. Sand filters following activated sludge treatment plants shall be subject to the same setback distances as the treatment plant (see paragraph (13)(B)1. of this rule). Open sand filters following septic tanks shall be located a minimum of two hundred feet (200') from future or existing residences or other establishments. Buried sand filters shall be located a minimum of one hundred feet (100') from any water supply structure and fifty feet (50') from any residence or establishment. Siting of buried sand filters shall consider access needed for maintenance and repairs by construction equipment.

2. General. Sand filter bottoms are generally constructed of unfilled earth, however liners or poured concrete bottoms may be required in areas subject to potential groundwater contamination. All buried and open intermittent sand filters shall be dosed. Sand for sand filters may be either natural sand or manufactured sand. Manufactured sand shall be chat sand produced from flint chat in the Joplin area, fines manufactured from igneous rocks or chert gravel may be used. Finely crushed limestone or dolomite is not acceptable.

3. Buried sand filters. A buried sand filter shall consist of one filtering bed or two (2) or more filtering beds connected in series and separated by a minimum of six feet (6') of undisturbed earth. Two (2) or more filter beds are required where a high degree of treatment is required or where sand filter media with an effective size of one millimeter (1 mm) or greater is utilized. Each bed shall contain horizontal sets of distribution lines and collector lines. These lines shall be equivalent to schedule 40 PVC pipe or other suitable materials.

A. One (1) collector line shall be provided for each six feet (6') of width or fraction thereof. A minimum of two (2) collector lines shall be provided. The upper end of each collector line shall be sealed or plugged. The collector lines shall be laid to a grade of one inch (1") in ten feet (10'). The tops of open joints in the collector lines may be covered with tarred felt (tar paper) to prevent intrusion of the media.

B. Gravel three-fourths inch to two and one-half inches (3/4"–2 1/2") in size shall be placed around and over the lower collector lines until there is a minimum of four inches (4") of gravel over the pipes. The gravel shall be overlain with a minimum of three inches (3") of washed pea gravel one-eighth inch to three-eighth inch (1/8–3/8") size interfacing with the filter media.

C. A minimum of twenty-four inches (24") of coarse washed sand shall be placed over the pea gravel. The sand shall have an effective size of one-half to two milliliters (.5–2 ml.) with a uniformity coefficient of less than three and one-half (3.5). Not more than one percent (1%) of the media shall be less than thirteen hundredths millimeters (.13 mm.) in size.

D. Six inches (6") of gravel three-fourths to two and one-half inches (3/4–2 1/2") in size shall be placed upon the sand in the bed.

E. Distribution lines shall be level and shall be horizontally spaced a maximum of three feet (3') apart center to center. Enough gravel shall be carefully placed to cover the distributors.

F. Venting shall be placed on the downstream end of the distribution lines with each distribution line being vented or connected to a common vent. Vents shall extend at least twelve inches (12") above the ground surface with the outlet screened or provided with a perforated cap.

G. A layer of material such as unbacked, rolled three and one-half inches (3 1/2") thick fiberglass insulation, untreated building paper of forty to sixty pound (40–60 lb.) weight, synthetic drainage fabric or four to six inches (4–6") of straw shall be placed upon the top of the upper layer of gravel. A minimum of twelve inches (12") of backfill shall be provided over the beds.

H. A distribution box shall be provided for each filter bed. The distribution boxes shall be placed upon undisturbed earth outside the filter bed. Separate watertight lines shall be provided leading from the distribution boxes to each of the distributor lines in the beds.

I. All buried sand filters shall be dosed by use of either pumps or dosing siphons. The dosing system shall be designed to flood the entire filter during the dosing cycle. A dosing frequency of greater than two (2) times per day is recommended. The dosing volume should be sufficient to fill the voids in the gravel to a depth of at least four inches (4").

(I) A pump shall be installed when adequate elevation is not available for the system to operate by gravity. A pump is also required when two (2) filters are required in order to dose the effluent from the first filter to the second filter. The pump shall be of corrosion-resistant material. The pump shall be installed in a watertight pit.

(II) Dosing siphons may be used between the septic tank and first filter bed when elevation permits their use. Dosing siphons shall be installed with strict adherence to the manufacturer's instructions. The dosing tank shall be of such size that the siphon will flood the entire filter during the dosing cycle.

J. Septic tank effluent application rates for buried sand filters shall not exceed one gallon (1 gal.) per day per square foot for single bed filters using sand media with an effective size less than one millimeter (1 mm) and not more than one and one-half gallons (1/2 gals.) per day per square foot when using two (2) or more filters with sand that has an effective size of greater than one millimeter (1 mm). The maximum organic loading for a buried sand filter shall be one and seventy-five hundredths pounds (1 7/5 lbs.) of BOD per day per one thousand (1000) square feet. Extended aeration treatment plant effluent may be applied to buried sand filters at a rate of up to one and one-half gallons (1 1/2 gals.) per day per square foot. Total surface area for any sand filter shall not be less than two hundred (200) square feet.

K. There shall be no construction, such as buildings or concrete driveways, covering any part of a buried sand filter.

4. Open sand filters. Media characteristics and underdrain systems for open sand filters are similar to those for buried sand filters. Distribution is often provided through pipelines and directed on splash plates located at the center or corners of the sand surface. Occasionally troughs or spray nozzles are employed as well and ridge and furrow application has been successful during winter operation in severe climatic conditions. Dosing of the filter should provide for flooding the bed to a depth of approximately two inches (2") or one and one-fourth gallons (1 1/4 gals.) per square foot. Dosing frequency is usually greater than two (2) times per day. For coarser media (greater than five-tenths millimeters (0.5 mm)), a dosing frequency greater than four (4) times per day is desirable. Higher acceptable loadings on these filters as compared to buried filters relate primarily to the accessibility of the filter surface for maintenance. Gravel is not used on top of the sand media and the distribution pipes are normally exposed above the surface.

A. The media used in the filters should be from locally available sources, however, the effective size should be at least three-tenths millimeters (0.3 mm) and the uniformity coefficient must be less than three and one-half (3 1/2) and there shall be no more than one percent (1%) smaller than thirteen-hundredths millimeters (.13 mm).

The media should have an effective size of less than one and two-tenths millimeters (1.2 mm) or treatment efficiency will be impaired. The sand must be free of any clay, limestone or appreciable amounts of organic material. The operating authority or owner of the treatment facility should be aware that the smaller the effective size of the sand, the more maintenance of the filter bed will be required. No sand shall be used unless a sieve analysis has been performed on the material delivered to the site. A copy of the report on sieve analysis shall be submitted to the department with the final operating permit application.

B. Filter walls shall be of concrete or masonry. They shall extend at least six inches (6") above the top of the sand bed and at least six inches (6") above the adjacent ground surface. The filter surface should be protected from runoff and diversion ditches. Berms will be required as the need indicates.

C. Distribution to the filter may be by means of troughs laid on the surface, pipelines discharging to splash plates located at the center or corners of the filter or spray distributors. Care must be taken to insure that lines discharging directly to the filter surface do not erode the sand surface. The use of curbs around splash plates or large stones placed around the periphery of the plates will reduce the scour. When troughs or point discharges are used, they should be located so that the maximum lateral travel over the sand is not more than twenty feet (20'). The design of the distribution system shall assure that the effluent will be evenly distributed from each point discharge or trough or spray nozzle. Dosed distribution boxes may be appropriate in some situations. A layer of washed pea gravel placed over the filter media may also be employed to avoid surface erosion. This practice will create maintenance difficulties when it is time to rake or remove a portion of the media surface.

D. Open sand filters may be covered to protect against severe weather conditions and to avoid encroachment of weeds or animals. The cover also serves to reduce odor conditions. Covers may be constructed of treated wooden planks, galvanized metal or other suitable materials. Screens or hardware cloth mounted on wooden frames may also serve to protect filter surfaces. Where weather conditions dictate, covers should be insulated. A space of twelve to twenty-four inches (12–24") should be allowed between the insulated cover and sand surface.

E. The hydraulic loading for open sand filters shall be from two to five gallons (2–5 gals.) per day per square foot when treating septic tank effluent and less than eight gallons (8 gals.) per day per square foot when treating the effluent from an extended aeration treatment plant. In choosing what loading rate to use, the engineer should consider effective size of the media and maintenance requirements. The maximum organic loading rate to open sand filters shall be five and thirteen-hundredths pounds (5.13 lbs.) of applied BOD per day per one thousand (1000) square feet.

F. Dual filters each sized for the design flow are required for treating septic tank effluent. Single filters are adequate for extended aeration plant effluent except that plants receiving and treating wastewaters stronger than domestic type waste (less than three hundred (300) mg/l influent BOD) shall be provided with dual filters. A diversion box shall be provided where two (2) or more beds are used.

G. Open sand filters shall be fenced in accordance with subsection (11)(A) of this rule.

5. High rate sand filters. High rate sand filtration may be used following extended aeration type treatment plants with flow equalization. Design of high rate sand filters shall be in accordance with 10 CSR 20-8.210 Supplemental Treatment Processes, section (4).

(D) Disinfection. Disinfection shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Disinfection can be accomplished with chlorine gas, calcium hypochlorite, sodium hypochlorite, iodine, bromine, ozone, chlorine dioxide and ultraviolet irradiation. For the range of flows covered by this rule, calcium or sodium hypochlorite are the most commonly used. Criteria for their use follow:

1. Design capacity. Chlorinators shall be designed to have adequate capacity to produce a total chlorine residual of one-half milligram per liter (1/2) mg/l after fifteen (15) minutes of contact time at the peak rate of flow. For typical domestic wastewater the following dosing capacity is recommended:

Pond Effluent	Extended Aeration Effluent	Sand Filter Effluent
20–30	10–25 mg/l	1–5 mg/l

2. Contact tanks. The chlorine contact tank shall be constructed to provide a minimum of fifteen (15) minutes of contact at the peak flow rate. For slow rate sand filter effluent, consideration should be given to an orifice-controlled discharge to the chlorine contact tank in order to avoid excessive size tanks. No orifice shall be less than one and one-half inches (1 1/2") in diameter. Baffling for serpentine flow shall be provided to minimize short circuiting. Baffles shall be designed to provide a length-to-width ratio of at least forty to one (40:1). Provisions shall be made for draining the tank to remove sludge with the sludge to be returned to either process or sludge holding facilities. Duplicate tanks are recommended.

3. Chlorinator housing. Chlorinators, with the exception of tablet type chlorinators, shall be housed in a separate enclosure which is properly ventilated and heated if winter operation is required. The chlorinator housings shall be equipped with mechanical ventilation with the inlet located near the floor. Ventilation equipment shall have sufficient capacity for providing a minimum of one (1) air change per minute; and

4. Dechlorination. Dechlorination shall be provided when required by 10 CSR 20-7.015 Effluent Regulations. Dechlorination chemicals shall be thoroughly mixed with the effluent, however no contact tank is required. Effluent reaeration may be required after dechlorination to insure adequate dissolved oxygen concentration. Special care should be taken not to allow calcium or sodium hypochlorite to mix with dechlorination chemicals during storage or handling. Dechlorinated effluent shall be monitored for chlorine residual and dissolved oxygen in accordance with discharge permit requirements.

(14) On-site Wastewater Treatment and Disposal. On-site wastewater treatment and disposal is a method of treatment involving pretreatment with a septic tank or extended aeration unit and further treatment and final disposal through soil adsorption. Soil adsorption is usually accomplished with the use of subsurface trenches, beds and elevated sand mounds. Land application of effluent from ponds is another method for a no-discharge system, however criteria for land application may be found in section (15) of this rule. This section also covers the criteria for engineering reports as required by 10 CSR 20-6.030 Disposal of Wastewater in Subdivisions.

(A) Engineer's Report—Single Family Wastewater Treatment Systems. An engineer's report required by 10 CSR 20-6.030 must demonstrate to the satisfaction of the department that the lot sizes, topography and soils in the subdivision are such that single family residence wastewater treatment systems may be used without causing a violation of the Missouri Clean Water Law and regulations. Also the design of the single family residence wastewater treatment systems will be in accordance with this rule. Criteria for an engineer's report that addresses these requirements are as follows:

Schedule JAM-5

1. General. A drawing or preliminary plat of the proposed subdivision that shows the individual lots and lot sizes must be submitted with the engineer's report. A copy of the geological evaluation, as required by 10 CSR 20-6.030, must be included with the report also. If county soils maps are available, the approximate soil boundaries must be shown on the plat or drawing.

A. The drawing or preliminary plat should show any existing water supplies or wastewater treatment systems. The proposed type of water supply must be indicated. If the development went from nonregulated to the number of lots to be regulated, the engineer should report on the method of wastewater treatment and disposal on the existing homes, whether or not the systems are surfacing and whether or not the effluent is crossing property lines. In areas of existing homes and potential groundwater contamination, the engineer should report on whether or not the wells serving the existing homes have had any history of contamination.

B. If no well records are available, the engineer should strive to have at least twenty-five percent (25%) of the wells tested. The wells should be tested for parameters recommended by the Missouri Department of Health. All information pertaining to failing systems or contaminated wells shall be shown on the plat or drawing. In these situations, the engineer should make recommendations for any deficiencies in the existing systems;

2. Lot sizes. The engineer's report must demonstrate that the lot sizes are large enough to satisfy the required set-back distances as required in 10 CSR 20-6.030 and 10 CSR 20-8.021. The lot size must be large enough for a soil adsorption system and repair area that is the same size as the original system in suitable soils;

3. Topography. The engineer's report must indicate that the areas where the soil adsorption systems will be sited are within the limits for slope as required in 10 CSR 20-8.021;

4. Soils. The location of all soil borings, percolation tests, backhoe pits or depth to bedrock determinations must be indicated on the drawing or plat. All these sites must be marked in the field by placing a lath at the hole or boring and writing on the lath whether the soil is suitable or unsuitable. The location of all these soils investigations must be at the most probable location of the sewage disposal area and based upon the most probable location of the residence.

A. There must be at least one (1) percolation test or soils investigation boring or pit on each lot in the subdivision. The soils investigation or percolation testing must continue on a lot until suitable conditions are found or the lot will not be considered for approval. Percolation tests and soils investigations must be in accordance with 10 CSR 20-8.021.

B. In some cases, where there are severe geological limitations for groundwater contamination, percolation tests and determination of soil morphological characteristics will not be sufficient. Particle size analysis or the percentage of rock fragments and depth to bedrock or seasonally high water table will be required in addition to the normal site evaluation. In some cases the additional requirements may apply when the geological limitations are moderate;

5. The proposed method of treatment and disposal, including soil loading rates and design, shall be in accordance with 10 CSR 20-8.021. The engineer's report must demonstrate that, based upon the site evaluations, there are sufficient suitable site conditions to design systems in accordance with 10 CSR 20-8.021. The report must also show the generic sizing of the different type of systems proposed;

6. The engineer's report must contain the name(s) and address(es) of the owner(s) and/or developer(s) with supporting documentation of the owner(s) and/or developer(s) approval of the report; and

7. The department may require provisions such as restricted covenants to assure that the proposed single family residence wastewater treatment systems will be constructed in accordance with 10 CSR 20-8.021 and the engineer's report unless other site evaluations by a person with the qualifications contained in this rule determines that the requirements of 10 CSR 20-8.021 can be met with a different design.

(B) On-site Systems Other Than Single Family Residences. On-site systems serving more than a single family residence or commercial establishment shall be designed in accordance with 10 CSR 20-8.021 provided that the design flow is less than fifteen hundred gallons (1500 gals.) per day. For on-site systems that are designed for more than fifteen hundred gallons (1500 gals.) per day, the criteria in this section shall be used in addition to the criteria contained in 10 CSR 20-8.021.

1. Engineer's report. An engineer's report is required for all on-site systems with design flows greater than fifteen hundred gallons (1500 gals.) per day. The engineer's report must contain the following in addition to the requirements of section (3) of this rule:

A. A geological evaluation of the proposed soil adsorption site must be performed by the Department of Natural Resources, Division of Geology and Land Survey;

B. For design flows greater than fifteen hundred gallons (1500 gals.) per day but less than three thousand gallons (3000 gals.) per day. The use of percolation tests at depths of three feet (3') in addition to soil pit observations to a depth of six feet (6') are the minimum site evaluation requirements. Analysis of the soil morphological characteristics may be used in place of percolation tests. Depth to bedrock from the bottom of the soil adsorption system must be six feet (6'). The following design parameters must be used:

(I) The slowest acceptable percolation rate is forty-five minutes (45 min.) per inch or a minimum permeability of six-tenths to two inches (.6–2") per hour;

(II) Depth to seasonally high water table shall be a minimum of four feet (4') from the soil adsorption bottom. Depth from the soil adsorption system bottom to a restrictive layer or impermeable bedrock or mottling is six feet (6');

(III) The system shall be divided into a minimum of two (2) soil adsorption areas with each area sized for seventy-five percent (75%) of the design flow. The systems must be dosed with either a siphon or pump in order to achieve distribution between the lines or beds;

(IV) Slopes shall not exceed fifteen percent (15%). Linear loading rates and landscape drainage shall be sufficient to prevent oversaturation of the soil adsorption system at the lowest elevation in the system; and

(V) In areas of highly permeable bedrock and where there is groundwater contamination potential, the chert content must be less than forty percent (40%) for a depth of ten feet (10'). In areas where the chert content is less than sixty percent (60%) for ten feet (10') below the soil adsorption system and the total depth to bedrock is greater than thirty feet (30'), soil adsorption may be used. In these areas of potential groundwater contamination, groundwater monitoring wells may be required if recommended by the Division of Geology and Land Survey. In some cases where Karstification is well developed, monitoring of area springs may be required; and

C. For design flows greater than three thousand gallons (3000 gals.) per day, all requirements and limitations previously mentioned in this section shall apply and the following limitations shall apply:

(I) In general, sites will not be approved where the geological limitations are severe and in some cases where the geological limitations are moderate;

(II) Groundwater monitoring may be required in areas where potable drinking water exists and there is a significant potential for contamination. The recommendations as to the number and construction details for groundwater monitoring wells from the Division of Geology and Land Survey will be followed;

(III) Soils shall be evaluated to a restrictive layer, bedrock or seasonally high perched water table. Calculations shall be submitted which show the predicted maximum height of the groundwater mound under the system or a perched groundwater mound. The minimum distance between the soil adsorption bottom and the maximum groundwater mound shall be four feet (4'); and

(IV) All hydraulic calculations on the pumps, siphons and distribution system shall be submitted.

(15) Land Application of Wastewater. This section applies to two (2) methods of land application which are slow rate (irrigation) and overland flow. The summary of design data and general layout shall contain pertinent information on the proposed site including location, geology, soil conditions, area for expansion, groundwater conditions and any other factors which may affect the feasibility and acceptability of the proposal. The summary of design data shall also include pretreatment and storage requirements, the design application rates and monitoring, application equipment, and operation and maintenance requirements. The source should be given for any information used by the consultant in design.

(A) Site Considerations. The following information concerning the site shall be provided:

1. Legal description of the disposal site;

2. The location of all existing and proposed residences, commercial or industrial developments, roads, ground or surface water supplies and wells within one-half (1/2) mile of the proposed site;

3. Available land area, both gross and net areas (excluding roads, right-of-way encroachments, stream channels and unusable soils);

4. Distance from the pretreatment and the storage facilities to the application site including elevation differential;

5. Proximity of site to industrial, commercial, residential developments, surface water streams, potable water wells, public use areas such as parks, cemeteries and wildlife sanctuaries;

6. Present and future land and groundwater uses;

7. A summary describing the existing vegetation of the area;

8. A description including maps showing elevations and contours of the site and adjacent areas which may be suitable for expansion. Specific information on the maximum and average slopes of the site must be provided; and

9. The department may require a geological evaluation of the proposed land application site prepared by the Department of Natural Resources, Division of Geology and Land Survey. A geologic report is not required for application rates that will not exceed twenty-four inches (24") of applied wastewater per year for typical domestic wastewater lagoon effluent.

(B) Wetted Application Area. The wetted application area is the land area which is normally wetted by wastewater application. The wetted application area must conform to the following criteria:

1. Flood-prone areas which flood at a frequency greater than once every ten (10) years should not be the sole source of land application;

2. The wetted application area shall be established at least one hundred fifty feet (150') from existing dwellings or public use areas, excluding roads or highways. In addition the wetted application area shall be at least fifty feet (50') inside the property line. Distances may be reduced depending upon the extent of pretreatment and operational techniques. One-half (1/2) the required distances may be used if the wastewater is disinfected in accordance with section (13) of this rule;

3. The wetted application area should be at least three hundred feet (300') from any sinkhole, losing stream or other structure or physiographic feature that may provide direct connection between the ground water table and the surface;

4. The wetted application area shall be at least three hundred feet (300') from any existing potable water supply well not located on the property. Adequate protection shall be provided for wells located on the application site; and

5. The application area should be fenced and posted along public roads and public use areas. Fencing is not required if the wastewater is disinfected prior to application or if other suitable barriers are provided or if the wetted application area is located in areas where access is limited. A minimum of one (1) sign should be placed on each side of the application area. The perimeter distance between any two (2) signs should not exceed five hundred feet (500'). Each sign should clearly identify the nature of the facility and advise against trespassing in letters not less than two inches (2") high.

(C) Soils Information. The department may require that the soil types and characteristics for the top five feet (5') of soil be investigated if applied wastewater will exceed twenty-four inches (24") per year. Unless required otherwise by the department, soils information shall include soil series name, soil texture, soil permeability and water-holding capacity. If a county soils map is available, the approximate boundaries of the different soils shall be shown. If a published soil survey is not available, the soils shall be classified by a professional soil scientist. In areas of soluble limestone and dolomite, where there is a potential for groundwater contamination, chert or stone content shall be determined to a depth of five feet (5'). Depth to restrictive layers such as fragipans or claypans shall be determined. Recommendations by the Division of Geology and Land Survey for further soils investigations shall be complied with.

1. The wetted application area should have a soil mantle of at least five feet (5') overlying any sand or gravel strata.

2. The topography of the site and adjacent land shall be evaluated for areas of potential erosion. The effects of both applied wastewater and storm runoff shall be considered. Special consideration should be given to the period of construction and system start-up when vegetative cover may be lacking or not fully developed.

(D) Preapplication Treatment. As a minimum, treatment prior to land application shall provide treatment equivalent to that obtained from a primary wastewater pond cell designed and constructed in accordance with section (13) of this rule, except that the pond depth may be increased to include wastewater storage on top of the primary volume. Separate storage cells may also be used. The maximum organic loading on the primary cell(s) at a water depth of three feet (3') shall not exceed thirty-four pounds (34 lbs.) of BOD per acre per day. The normal operating level for all ponds should be between the two-foot (2') level and the high water level. A permanent depth measurement gauge or marker shall be installed in the pond(s) and shall be easily readable at one-foot (1') increments or smaller. The gauge shall be placed in a suitable location where it is easily accessible during routine operations.

(E) Operation and Maintenance Plan. An operation and maintenance plan shall be provided to explain the key operating procedures at a level easily understood by the owner and the operator of the facility. An outline and brief summary of operations shall be provided as part of the engineering report. A detailed operation and maintenance plan shall

Schedule JAM-5

be included as part of the engineering plans and at a minimum shall address maintenance of mechanical equipment and vegetative cover, monitoring, record keeping, operating procedures, application scheduling and winterization of the system.

(F) Land Application Facility. This rule provides design criteria for a standardized conservative land application system. For the range of flows covered by this rule, the maximum application rate for typical domestic wastewater shall be forty to one hundred inches (40–100") of applied wastewater per year depending on soil characteristics. For higher application rates, additional soils and geologic information, detailed site specific design proposals and supporting documentation shall be submitted to justify the proposed design. These designs should follow the requirements in 10 CSR 20-8.220. For irrigation the recommended design procedures for domestic wastewaters may be found in the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625/1-81-013).

1. Crops and vegetation. A description of the crops or vegetation to be grown is required for all systems in which vegetation is to be an integral part of the treatment system. This includes all slow rate and overland flow systems. The use of wastewater for irrigation of truck farms growing vegetables will not be approved. The following information shall be provided:

A. Compatibility of the crop with site characteristics and design hydraulic loading rates;

B. Cultivation and harvesting requirements; and

C. Crop management.

2. Storage facility. Storage requirements shall be based on the design wastewater flows and net rainfall minus evaporation expected for a one (1) in ten (10) year return frequency for the storage period selected. The storage volume for wastewater stabilization ponds shall be calculated based on the useable volume above the two-foot (2') level. The minimum total days' storage required for no discharge ranges from sixty (60) days in southern Missouri to one hundred twenty (120) days in northern Missouri. These requirements assume that a permanent cover crop is in place and the primary purpose of the system is wastewater treatment. If the system uses row crops, or crop production is the primary goal, storage should be increased to correspond with crop planting and harvesting schedules. An exception to this is a system where flows are generated only during the application period. A storage capacity of forty-five (45) days or the flow generated during the period of operation, whichever is less, must be provided.

3. Equipment. The following shall be considered in the design of the land application equipment:

A. Any spray application equipment specified shall minimize the formation of aerosols;

B. The pumping system and distribution system shall be sized for the flow and operating pressure requirements of the distribution equipment and the application restrictions of the soils and topography;

C. Provisions shall be made for draining the pipes to prevent freezing if pipes are located above the frost line;

D. A suitable structure shall be provided for either a portable pumping unit or a permanent pump installation. The intake to the pumping system shall provide the capability for varying the withdrawal depth. The intake elevation should be maintained twelve to twenty-four inches (12–24") below the wastewater elevation. The intake shall be screened so as to minimize clogging of the sprinkler nozzle or distribution system orifices. For use of a portable pump, a stable platform and flexible intake line with flotation device to control depth of intake will be acceptable;

E. Thrust blocking of pressure pipes shall be provided. For use of above ground risers for sprinklers, a concrete pad and support bracing should be considered; and

F. Automatic or semi-automatic controls should be considered for shut off of the system after a prescribed wastewater application period. Manual start-up of the application system is recommended.

4. Soil permeability. Soil permeability shall be based on the most restrictive layer in the top five feet (5') of soil. Soils having permeability rates of two-tenths to two inches (.2–2") per hour are most suitable for irrigation. Values below two-tenths inch (.2") per hour may generally require special application equipment, reduced application rates or overland flow approach. Values above two inches (2") per hour will require reduced application rates to provide adequate residence time within the soil profile or will require additional soils and geologic information for depth to bedrock, depth to water table and recharge areas.

5. Slope. The maximum allowable slope of the wetted application area is twenty percent (20%).

6. Application rate. The application rate consists of an hourly application rate in inches per hour and daily, weekly and annual application rates in inches per acre. Application of wastewater will not be allowed during periods of ground frost, frozen soil or during rainfalls. The following shall apply to design application rates:

A. The hourly application rate should not exceed the design sustained permeability rate except for short periods when initial soil moisture is significantly below field capacity. The hourly rate shall not exceed one-half (1/2) the design sustained permeability for slopes exceeding ten percent (10%). However, in no case should the application rate be greater than one-half inch (1/2") per hour. For soil permeability of less than two-tenths inch (.2") per hour, the designed maximum application rate should be as low as practicable and shall not exceed two-tenths inch (.2") per hour;

B. The daily and weekly application rates should be based on soil moisture holding capacity, antecedent rainfall and depth to the most restrictive soil permeability. The application rate shall in no case exceed one inch (1") per day and three inches (3") per week; and

C. The design maximum annual application rate shall not exceed a range from four percent to ten percent (4%–10%) of the design sustained soil permeability rate for the number of days per year when soils are not frozen. The following shall apply to typical domestic wastewater lagoon effluent:

(I) Soil permeability less than two-tenths inch (.2") per hour. The maximum application rate shall be forty inches (40") of applied wastewater per year. The department may require lower application rates when there is evidence of fragipans, claypans or zones of seasonal saturation within the top two feet (2') of the soil profile;

(II) Soil permeability range from two-tenths inch (.2") per hour to two inches (2") per hour. The maximum application rate shall be one hundred inches (100") of applied wastewater per year. Lower rates may be required if there is evidence of seasonal saturation in the top five feet (5') of the soil profile or if there is a significant potential for groundwater contamination;

(III) Soil permeability ranges from two inches (2") per hour to six inches (6") per hour. The maximum application rate shall be sixty inches (60") of applied wastewater per year. The department may require lower rates if there is a significant potential for groundwater contamination; and

(IV) Soil permeability over six inches (6") per hour. The maximum application rate shall be twenty-four inches (24") of applied wastewater per year.

D. In no case shall the application rate result in the runoff of applied wastewater during or immediately following application.

7. Nitrogen Loading. Nitrogen application rates shall not exceed the amount of nitrogen that can be utilized by the vegetation to be grown. Typical domestic wastewater after lagoon storage can be expected to contain from five to eight milligrams per liter (5–8 mg/l) of ammonia nitrogen as N and less than one (1) mgl of nitrate nitrogen as N. Ammonia nitrogen can be adsorbed onto soil particles and retained in the soil for later use by plants and microorganisms. However, nitrate nitrogen is mobile and will readily leach through the soil profile if wastewater is applied faster than the vegetation or soil microbes can utilize the nitrates. If the applied wastewater is expected to provide more than one hundred fifty pounds (150 lbs.) of total nitrogen per acre annually or if the applied wastewater exceeds ten (10) mg/l of nitrate nitrogen as N, then calculations shall be submitted to show the amount of plant-available nitrogen provided and the amount of nitrogen that will be utilized by the vegetation to be grown.

8. Trace element loading. Consideration shall be given to the type and influence of any industrial wastes contributed to the wastewater stabilization pond. Typical domestic wastewater does not contain amounts of trace substances which are of concern for land application of wastewater under this rule. However, introduction of substances, such as excess sodium, chlorides, boron or other constituents, can have an adverse impact on soils and vegetation. Timber is more sensitive to these substances than grass or grain species. Wastewater suitable for general land application shall not exceed the trace element concentrations in Table 4-5 of the *U.S. Environmental Protection Agency Process Design Manual for Land Treatment of Municipal Wastewater* (EPA 625-1/81-013).

9. Public use areas. The following shall apply to the irrigation of public use areas with wastewater:

A. The wastewater shall be disinfected prior to land application (not storage) in accordance with section (13) of this rule. The wastewater shall contain as few of the indicator organisms as possible and in no case shall the irrigated wastewater contain more than two hundred (200) fecal coliform organisms per one hundred milliliters (100 ml);

B. The public shall not be allowed into an area when application is being conducted; and

C. For golf courses utilizing wastewater, all piping and sprinklers associated with the distribution or transmission of wastewater shall be color-coded and labeled or tagged to warn against the consumptive use of contents.

10. Grazing and harvesting deferment. Grazing of animals or harvesting of forage crops should be deferred for up to thirty (30) days following wastewater irrigation depending upon ambient air temperature and sunlight conditions. The following deferments shall be considered:

A. During the period from May 1 to October 30 of each year, the minimum deferment from grazing or forage harvesting shall be fourteen (14) days;

B. During the period from November 1 to April 30 of each year, the minimum deferment from grazing or forage harvesting shall be thirty (30) days;

C. Grazing of sewage irrigated land is generally not recommended for lactating dairy animals unless there has been a much longer deferment period. The recommendations of the State Milk Board shall be followed; and

D. Deferment may not be required for irrigation water that has been disinfected so that the water contains less than four hundred (400) fecal coliform organisms per one hundred milliliters (100 ml).

(G) Overland Flow. Overland flow distribution is accomplished by applying wastewater uniformly over relatively impermeable sloped surfaces which are vegetated. Part of the flow percolates into the ground, a portion is lost to evapotranspiration, while the remaining is collected and either discharged to a stream or reapplied on land.

1. Groundwater. The maximum groundwater elevation shall be at least two feet (2') below the application surface.

2. Slope. The land slope should be relatively uniform to prevent ponding and shall be in the range of two to eight percent (2–8%). For all overland flow systems, the slope must be nearly equal to a plane surface as possible and sloped in such a way as to prevent short-circuiting of the wastewater. No swales, depressions or gullies are permitted. The minimum length of slope for overland flow treatment is one hundred feet (100'). Two hundred feet (200') is the maximum length over which distribution of wastewater can be maintained.

3. Storage. The minimum amount of storage will range from forty-five (45) days in southern Missouri to ninety (90) days in northern Missouri. The applicant shall increase the storage facility to accommodate rainfall on the application site. This storage is then to be increased to accommodate any recirculation needed to comply with the discharge permit limitations.

4. Hydraulic loading. The recommended design hydraulic application rate is one and six-tenths inches (1.6") per day. The distribution system shall be designed to permit application on each field for eight to twelve (8–12) hours per day. Optimum wetting to drying cycle should range from a maximum of eight to twelve (8–12) hours on and a minimum of twelve to sixteen (12–16) hours off.

5. Distribution system. The system should be valved and manifolded to permit a portion of each application area to be taken out of service for grass mowing and/or harvesting. For facilities with flows less than fifteen thousand gallons (15,000 gals.) per day, the need to divide the overland flow plot into more than one (1) field is not necessarily required.

A. Sprinklers shall be placed down slope from the highest point on the application area at a distance equal to the radius of the sprinkler.

B. For surface distribution methods, such as gated pipe or bubbling orifice, gravel may be necessary to dissipate energy and insure uniform distribution of water.

6. Vegetation. Grasses must be selected for their resistance to continuously wet root conditions. Their growth should not be in clumps as this will result in the formation of rivulets of flow rather than a uniform sheet flow. Common grasses for this purpose have been reed canary grass, Italian rye, red top, tall fescue and Bermuda grass. Application is not allowed until a full grass cover has been established.

A. Vegetation harvest and removal is recommended. The vegetation must be cut just prior to maturity (every four to six (4–6) weeks) and physically removed from the site. Harvesting should be conducted when the soil conditions are dry enough to avoid creating ruts that would short-circuit the flow.

7. Collection ditches. A network of ditches must be constructed to intercept the runoff and channel it to the point of discharge or storage. They must be graded to prevent erosion yet at the same time they shall have sufficient slope to prevent ponding in low spots. The collection system must be designed to accept the added flow from rainfall runoff. If the collection ditch discharges to a stream, the effluent must meet the limitations and monitoring required in the discharge operating permit.

(16) Appendix I. This water balance study criteria is specific to newly-constructed ponds and to existing ponds when required by the department to perform a water balance. New ponds must be prefilled to at least the two-foot (2') level with clear water and this test conducted prior to the introduction of sewage to the ponds. The water level in the ponds must always remain above the two-foot

(2') riser during the test period to insure the measurement of pond level in the control structure will be accurate. It is advised to begin the test with a pond level several inches above the two-foot (2') riser level. Existing ponds must have at least three feet (3') of water in them for the test period. The study shall contain pertinent information that will be sufficient to establish the seepage rate of each cell within the pond system. All raw data should be presented along with the calculations used to formulate the conclusion.

(A) Two (2) methods for conducting this study are offered here. One method utilizes a Class A Weather Pan to measure evaporation. Standard procedures for setup and data gathering must be practiced where using a Class A Pan. The other technique, referred to as the Barrel Method, uses a simpler data gathering task and reduced calculations. Either method may be used to perform the water balance study. Due to the ease of data gathering and calculation, the Barrel Method is recommended. The following information must be generated and used in the calculation of the seepage rate of each cell individually within the pond system. The procedures identify data needed for using the Barrel Method or the Class A Weather Pan:

1. An accurate determination of the square footage of the cell must be made. Dimensions from the as built plans, if available, should be used to calculate this area at the height of the water level used during the water balance study. Pond floor measurements are usually given inside toe of dike to inside toe. Therefore, use the side slope ratio to calculate the added horizontal distance from the toe of slope to the dike at the water level used for the study;

2. No sewage inflow to the pond should be allowed until the test has been completed and approved. Inflow to the pond during the test period should be zero (0) and the inflow factor F will have a zero (0) value. If an unavoidable discharge or transfer of water to a cell must occur during the study period, that inflow must be accurately measured by either a flow recorder or by time clocks on pumps that have been calibrated at least twice during the study period. If an accurate measurement of flow cannot be made the test must be redone. If control structure slide gates or valves leak, they must be plugged for the duration of the test;

3. Rainfall measurement must be taken from a reliable rain gauge installed at the pond system. This data will be used directly in the seepage calculation when using the Class A Weather Pan or will be used as substantiation data if the Barrel Method is used. Rainfall measurements must be used to account for runoff from the top of the berms and side slopes. An appropriate runoff coefficient shall be used. The runoff coefficient should consider the antecedent conditions, amount of rainfall and duration of rainfall. Rainfall shall be measured daily during the normal work week;

4. Water losses through evaporation must be incorporated into the seepage calculation either by the use of a United States Weather Bureau Class A Land Evaporation Pan or by the use of barrels. Standard methods for use and placement of a Class A Weather Pan must be followed. The Barrel Method does not directly calculate the value of evaporation but gives a joint value for rainfall and evaporation. If a Class A Pan is used, an evaporation pan factor (to obtain a realistic value for actual pond evaporation) should be used;

5. In order to provide the highest degree of accuracy for the water balance test, no discharges should be made from the cells during the test period. Therefore, the outflow factor O in the seepage calculation should be zero (0). If discharge transfer from a cell is unavoidable during the test period, accurate flow measurements must be made by either flow recorder, time clocks or pumps (that have been calibrated at least twice during the discharge period) or some other form of accurate measurement; and

6. The water level of each cell should be recorded to the nearest one-sixteenth (1/16) of an inch. The measurements should be made within the manhole control structure from a fixed measuring device. This fixed device may be a temporarily fixed ruler installed for the test period only. Water level measurements shall be taken daily during a normal five (5)-day work week.

(B) A large (approximately fifty-five gallon (55 gal.)), clean (no oil or grease film), light-colored (inside and outside) barrel can be used to measure the rainfall and evaporation on a pond cell. At least three (3) barrels must be strategically located within the pond system with a surrounding baffle on each to avoid possible splash over. Barrels should be placed all in one (1) cell if only that cell is being tested at the time. If more than one (1) cell is being tested during the test period, the barrels should be arranged throughout the cells with a minimum of one (1) barrel per cell. Place the barrels where they are accessible for reading the water depths. The top of the barrel should extend at least one foot (1') but not more than two feet (2') above the water level in the cell. The barrel top should be cut (if necessary) to within these dimensions to accurately reflect the evaporation and rainfall changes to the pond contents. A measuring device should be fixed to the inside of the barrel to facilitate accurate water depth measurement to the nearest one-sixteenth (1/16) of an inch. In case splash over or overturning of a barrel occurs, the close results of the other two (2) barrels will validate the test. If one (1) barrel provides invalid data, that data should be presented but not included in the calculation. If all sets of data are reasonable to use, the data from the three (3) barrels should be averaged for the final calculation of the individual seepage rate for each cell.

1. The barrel must be on a firm footing with the bottom of the barrel on the bottom of the pond. The top of the barrel should always remain level.

2. The water level in the barrel should be initially set as close as possible to the water level outside the barrel. At the daily readings this water level in the barrel may need to be adjusted up or down to again be as close as possible to the outside water level. These resettings of the water levels in the barrel should be closely measured and recorded so that they are not included in the overall increase or drop of the barrel water elevation for the length of the study. Keeping the water level inside the barrel close to the water level outside the barrel will increase the reliability that the evaporation inside the barrel will match that of the rest of the pond. However, do not adjust the water level in the barrel during the test unless it varies from the water level outside the barrel by more than five inches (5").

(C) The necessary data should be obtained on a daily basis for a period of thirty (30) days during a period of time when no freezing can occur or when air temperatures go above ninety to ninety-five degrees Fahrenheit (90–95 °F). If realistic estimates of surface runoff into the pond cannot be made, the data taken on days with rainfall should not be used in the calculations. In any case there must be thirty (30) days of data.

1. The net seepage rate should be given in gallons per acre per day calculated for each cell over the cell bottom and dike areas by using the following equation:

$$S = F + R—E—O—WL$$

Where:

WL = change in height of water level in a pond cell given in inches after taking rainfall and evaporation into account. WL will be a positive number for an increase in pond depth and will be a negative number for a decrease in pond depth. Reading will be taken in the control structure. When using the Barrel Method, WL will be calculated in the following manner:

WL = Hp—Hb

Where:

WL = the pond water elevation change accounting for rainfall and evaporation. A positive number indicates an increase in the pond level and a negative number will indicate a drop in the pond water level;

Hp = the change in the water level within the pond. A positive number is an increase in the water level and a negative number equals the drop of water level. This measurement should be made in the control structure;

Hb = the change of water level measured in the barrel. A positive number is an increase in water level and a negative number equals a drop in the water level. This measurement should be made in the barrel;

S = net seepage rate from a cell calculated to inches of water elevation and converted to gallons per acre per day. A positive number equals the amount of seepage the pond experiences; a negative number would indicate a negative seepage rate which is a net gain of water in the pond system;

F = wastewater flow into the cell during the study period should be zero (0). If there is an inflow, however, it would be given in gallons and should be converted to inches of water elevation over the cell;

R = rainfall directly on pond system calculated in inches during the study period. When the Barrel Method is used, this factor will not be included in the seepage calculations as it is automatically accounted for in the barrel measurement. However, runoff from the berms must be accounted for and calculated as inches of water in the pond;

E = evaporation from the pond surface measured in inches over the duration of the study period. When the Barrel Method is used, this factor will not be included in the calculation as it is automatically accounted for in the barrel measurement; and

O = outflow from the pond cell and/or transfer of contents from a cell should not occur during the study period. If a discharge does occur, however, it should be given in gallons and converted to inches of water elevation over the cell.

Note: When data taken on rainfall days is eliminated, the days between rainfall events essentially become short separate water balance studies. In this case the seepage rate will become the average of the studies.

(17) Appendix II. This appendix contains additional criteria for design and construction of liners in wastewater stabilization ponds.

(A) Site Evaluation. A preliminary investigation for a pond site should be undertaken to screen a study area for potential sites before a detailed site investigation, if required, is undertaken. The purpose of the investigation is to assemble available information to determine if soil borings and soil tests are required to design a pond which will meet the seepage requirements. The investigation should be done using data such as Soil Conservation Service (SCS) County Soil Surveys, U.S. Geological Survey topographic maps and the required geological evaluation from the Department of Natural Resources, Division of Geology and Land Survey. Visual inspection of the area noting topography, wet areas, vegetation and ditching is useful and may be necessary, particularly if maps are not detailed and/or soil maps do not exist. Information gathered from this investigation should be particularly useful in evaluation of the site with regard to estimating possible soil variability and suitability.

1. All potential pond sites will receive a rating from the geological evaluation. The rating will infer the relative geological limitations for designing and constructing a pond at the site in question. Whenever the geological evaluation indicates that a site has slight limitations, the requirements for additional site investigation as set forth in subsection (17)(B) of this rule, may not be required by the department. The department may require that the results of density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

2. Whenever a site has moderate geological limitations, the department may require one (1) or all of the requirements for a detailed site investigation as set forth in subsection (17)(B) of this rule. The department may require density tests, taken on the finished pond liner, be submitted and approved prior to putting the pond into operation.

3. Sites that have severe geological limitations for construction of wastewater stabilization ponds will be reviewed on a case-by-case basis. The department may require artificial liners in these situations. In general, where there is high collapse potential due to bedrock and soil conditions, the use of ponds will not be allowed. Exceptions may be granted dependent upon the type of liner proposed and where the geological considerations have been thoroughly evaluated so that the risk of groundwater contamination is minimized.

4. Where liners are used in storage or treatment basins for wastewaters of an industrial nature, the summary of design data shall document that the liner or storage structure material is capable of containing the wastewater for at least twenty (20) years and shall specify repair or replacement procedures in the event of leakage or damage to the seal. Secondary containment or leakage detection and collection devices shall be considered for corrosive or reactive wastewaters and for toxic materials. The department may require leakage testing in accordance with section (16) of this rule and submittal of density tests and/or coefficient of permeability on the finished liner prior to placing the structure into operation.

(B) Detailed Soils Investigation. If a detailed site investigation is needed to substantiate feasibility and design of a project at a selected site with regard to design requirements, the quantity and quality of soil materials on site (and borrow) must be identified and evaluated for use in the pond and/or liner construction. The design concepts and objectives of the investigation should be made clear by the consulting engineer to the qualified soil engineering party doing the field work so that an investigation strategy can be developed and sufficient data collected. Most important, an identification of the volume of the soil needed for the liner must be determined. The department may require the following to be included in the soils investigation:

1. Exploration shall be sufficient to identify and define the quantities and quality of the soil liner materials. The use of test pits, split barrel or thin wall sampling or a combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed. The following information, in whole or in part, may be required by the department:

A. Atterburg limits;

B. Standard Proctor density (moisture/density relationships);

C. Coefficient of permeability (undisturbed and remolded);

D. Depth to bedrock;

E. Particle size analysis; and

F. Depth to seasonal high groundwater table; and

2. Information gathered from the investigation should be presented on a base map drawn to scale and referenced to U.S. Geological Survey datum. Slope, landscape position and other surface features should also be included. Stratigraphy of soils should be shown using cross sections or fence diagrams when soil liner material is to be identified. Copies of original boring and other soil test logs shall also be included. An interpretation of the collected data shall be incorporated into the report. Any site constraints and how they will be dealt with should be discussed.

(C) Design. The following criteria are for design and construction of soil liners. Engineering reports, plans and specifications should address these criteria.

Schedule JAM-5

1. The soils used for construction of a wastewater stabilization pond liner should meet the following minimum specifications:

A. Be classified under the Unified Soil Classification Systems as Cl, Ch, Gc or Sc;

B. Allow more than fifty percent (50%) passage through a No. 200 sieve;

C. Have a liquid limit equal to or greater than thirty (30);

D. Have a plasticity index equal to or greater than twenty (20); and

E. Have a coefficient of permeability equal to or less than 1×10^{-7} centimeters per second when compacted to ninety percent (90%) of standard proctor density with the moisture content between two percent (2%) below and four percent (4%) above the optimum moisture content;

2. The minimum thickness of the liner is twelve inches (12"). For soils which have a coefficient of permeability greater than 1×10^{-7} centimeter per second, liner thickness of more than twelve inches (12") may be required as set forth in subparagraph (13)(A)4.B. of this rule;

3. Normal construction methods will include scarification and compaction of base material to ninety percent (90%) standard proctor density at a moisture content that allows the material to be plastic. Construction of the liner material should be at a moisture content between two percent (2%) below and four percent (4%) above optimum and compaction of lifts generally not exceeding six inches (6") to greater than ninety percent (90%) standard proctor density. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The completed seal shall be maintained at or above the optimum water content until the pond is prefilled in accordance with subparagraph (13)(A)4.C. of this rule; and

4. If bentonite is proposed to be part of the liner construction, the following must be considered:

A. The bentonite should be high swelling and free flowing for uniform application. The application rate should be a minimum of two pounds (2 lbs.) per square foot. The water content of the soil-bentonite mixture should be at or up to four percent (4%) above the optimum for maximum compaction;

B. The bentonite should be spread with equipment that provides uniform application and minimizes wind drift. The application shall be split, so that one-half (1/2) is applied in one direction and the remaining half in a perpendicular direction on the pond floor and dikes. The bentonite shall be mixed into the soil to a uniform depth of at least four inches (4") and the liner should be compacted to at least ninety percent (90%) standard proctor density without the use of a sheepsfoot roller. The completed liner shall be covered with at least four inches (4") of fine textured soil and the liner shall be hydrated with fresh water prior to introduction of wastewater and kept at or above optimum water content until the pond is prefilled; and

C. At sites where the soils are considered to be aggregated cherty clays, the pond bottom below the bentonite seal should be either constructed as embankment or scarified to a depth of twelve inches (12") and compacted in six-inch (6") lifts to at least ninety percent (90%) standard proctor density. At least four inches (4") of fine soil shall be placed on top of the compacted pond bottom for mixing with the bentonite. The maximum size of rocks in the fine soil used for covering the soil-bentonite liner and in the soil-bentonite mixture should be one inch (1").

(D) Synthetic Liners. Requirements for thickness of synthetic seals may vary due to liner material but the liner thickness shall be no less than two-hundredths inch (.02") or twenty (20) mil. Consideration should also be given to liners containing reinforcement in appropriate situations, such as sidewall slopes steeper than one to three (1:3) or pond depths greater than six feet (6'). Also in areas of cherty or gravelly soils, consideration should be given to using a geotextile under the liner or very thick polyethylene (80 mil) liners. Special care must be taken to select the appropriate material to perform under existing conditions.

1. Proper site preparations for synthetic liners are essential. The subsoil bed shall be sufficiently prepared to insure that all holes, rocks, stumps and other debris are eliminated. The subsoil shall be sieved or the area raked after grading to provide a smooth, flat surface free of stones and other sharp objects. A bedding of two to four inches (2–4") of sand or clean soil free of stones greater than three-eighths inch (3/8") or other sharp objects shall be provided. Soil shall be well compacted and sterilized to kill vegetation. If gas generation from decaying organic material or air pumping from a fluctuating groundwater table is a potential problem, a method of gas venting must be proposed. The method utilized will be dependent on the existing conditions at the site.

2. Liner panels should be laid out to minimize seams with an overlap of four to six inches (4–6"). Careful application of the seaming method is essential. The anchor trench should have a minimum six-inch (6") depth and be placed at least nine to twelve inches (9–12") beyond the slope break at the dike. Care must be exercised in the backfilling of the anchor trench to insure the liner is not damaged. To prevent erosion, mechanical damage to the liner and hydraulic uplifting of the liner, a minimum backfill of twelve inches (12") of sand or finely textured soils on the top of the liner is recommended on the pond floor. On the side slopes this should consist of a minimum twelve-inch (12") primary fill of finely textured soil and possibly a minimum six-inch (6") secondary fill of rip-rap.

3. All seams should be inspected and the inspection reports should be submitted to the department prior to seepage testing if required. It is recommended that installation be done by contractors familiar with potential problems which can be encountered.

(E) Asphalt Liners. Asphalt liners have not been tried extensively in Missouri and may be approved on a case-by-case basis. If proposed, the following hydraulic asphalt mix conditions will apply at a minimum. Other conditions may be indicated as requirements based on the project specific review. Due to the potential of the seal lifting and cracking from groundwater and/or from the frost cycles, the groundwater depth and subsurface drainage in the dikes must be carefully considered in the design phase for the asphalt liner to be successful:

1. The aggregate for the mixture shall meet the quality requirements of *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, 1986, section 1002 and shall meet the following gradation requirements of (The Asphalt Institute) Hydraulic Mixtures A and B:

Slieve Size	Percent Passing	
	A	B
3/4"		100
1/2"	100	95–100
3/8"	95–100	84–94
#4	70–84	63–93
#8	52–69	46–65
#16	38–56	34–53
#30	27–44	25–42
#50	19–33	17–32
#100	13–24	12–23
#200	8–15*	8–15*

*Mineral filler may be required to meet the gradation requirements on the No. 200 sieve.

2. The asphalt incorporated into the mixture shall meet the requirements of AC-20, Table 2 of AASHTO designating M226, viscosity graded asphalt cement, except that the minimum penetration shall be eighty (80) rather than sixty (60).

3. Mix design criteria shall be as follows (Marshall Method ASTM D 1559):

A. Marshall Stability (35 blows/side) five hundred pounds (500 lbs.) minimum;

B. V.M.A., % 15 minimum;

C. Air Voids, % 0–2 (target value—1%);

and

D. Asphalt Cement, % (wt. of total mix) 6.5–9.5.

4. The liner should be constructed in accordance with the requirements specified in *Missouri Standard Specification for Highway Construction*, Missouri Highway and Transportation Commission, section 403, Asphaltic Concrete Pavement, except as modified or supplemented by the following:

A. The liner shall be four inches (4") thick at a minimum;

B. The liner shall be constructed in two (2) lifts, with each lift being approximately equal to one-half (1/2) the total surface thickness to within plus or minus one-half inch (1/2") tolerance;

C. Longitudinal joints between paver passes for the second layer should be offset from the joints in the lower layer by three feet (3');

D. Transverse joints in the second layer shall be offset from joints in the lower layer by at least three feet (3');

E. A tack coat of an emulsion such as CSS-1 or CSS-1h diluted one to one (1:1) with water and applied at an approximate rate of ten hundredths gallons (.10 gals.) per square yard should be applied between asphaltic lifts and on all vertical joints prior to placement of the next and/or adjacent lift. The tack coat between two (2) lifts should be uniformly distributed. All tacking should be done in accordance with MSSHC section 407, except as modified as described here; and

F. Placement of the hot-mix asphalt mixture shall be accomplished when the ambient temperature is above and fifty degrees Fahrenheit (50 °F.);

5. Upon completion of the construction of the hot-mix asphalt concrete liner and prior to filling of the basin with water or sewage, a surface treatment of asphalt cement should be applied to the entire basin to ensure a watertight basin and to reduce the rate of oxidation of the surface of the lining. An AC-20 should be used and applied at a rate of about twenty-five hundredths gallons (.25 gals.) per square yard. Two (2) applications may be necessary to achieve this rate. The surface should be clean, dry and free from loose material prior to the application;

6. The sides of the basin should be designed so that paving equipment may operate or on a four to one (4:1) slope (horizontal to vertical). The asphaltic surface should be extended up and onto the berm of the basin for a distance of at least three feet (3') beyond the point of intersection of the berm and side slope. This asphalt cap should be constructed around the basin; and

7. The subgrade or base for the slopes and bottom shall be constructed of MSSHC type 2 base material and shall be a minimum of one and one-half inches (1 1/2") and compacted to ninety-five percent (95%) standard proctor density. Prior to construction of the asphaltic concrete liner, the subgrade soil (type 2 base) on all side slopes should be treated with soil sterilants to prevent weed growth through the lining.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded and readopted: Filed Nov. 4, 1988, effective April 15, 1989.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.021 Individual Sewage Treatment Systems Standards
(Rescinded March 30, 1999)

AUTHORITY: section 644.026, RSMo 1986. Original rule filed Nov. 14, 1988, effective April 15, 1989. Rescinded: Filed July 13, 1998, effective March 30, 1999.

10 CSR 20-8.030 Design of Sewage Works
(Rescinded August 13, 1979)

AUTHORITY: section 204.026, RSMo Supp. 1973. Original rule filed July 17, 1961, effective July 27, 1961. Amended: Filed Oct. 3, 1962, effective Oct. 13, 1962. Amended: Filed Dec. 4, 1975, effective Dec. 14, 1975. Rescinded: Filed May 4, 1979, effective Aug. 13, 1979.

Op. Atty. Gen. No. 92, Bockenkamp (3-24-75)*. The City of Farmington may impose user charges pursuant to section 204.026(18), RSMo (Supp. 1973), to cover costs of operation and/or future expansion of a public sewer treatment facility constructed pursuant to a grant of federal funds under 33 USC, Sections 1281-1292, without the necessity of an election as provided in section 71.715, RSMo (1969).*

Op. Atty. Gen. No. 229, Smith (8-20-73)*. Municipalities and sewer districts have authority to make the user charges to industries required by the Federal Water Pollution Control Act amendments of 1972 and to establish the reserves for future expansion or reconstruction.*

10 CSR 20-8.110 Engineering—Reports, Plans, and Specifications

PURPOSE: The following criteria have been prepared as a guide for the preparation of engineering reports or facility plans and detail plans and specifications. This rule is to be used with rules 10 CSR 20-8.120 through 10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission in regard to adequacy of design, submission of plans, approval of plans, and approval of completed wastewater treatment facilities. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of all ASTM International standards, design manuals such as Water Environment Federation's Manuals of Practice (MOPs), and other sewer and wastewater treatment design manuals containing principles of accepted engineering practice. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from the 2004 edition of the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers ***Recommended Standards for Wastewater Facilities*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear.*

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the Missouri Department of Natural Resources (department) is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should," "recommend," "preferred," and the like, indicate the preference of the department for consideration by the design engineer.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(2) Applicability. This rule shall apply to all facilities with a design flow of one hundred thousand (100,000) gallons (378.5 m^3) per day or greater. This rule shall also apply to all facilities with a design flow of twenty-two thousand five hundred (22,500) gallons (85.2 m^3) per day or greater until such time as 10 CSR 20-8.020 is amended.

(3) General.

(A) Engineering Services. Engineering services are performed in three (3) steps—

1. Engineering report or facility plan;

2. Preparation of construction plans and specifications; and

3. Contractual documents, construction compliance, inspection, administration, and acceptance.

(B) 10 CSR 20-8.110 Engineering—Reports, Plans, and Specifications covers the items in paragraphs (3)(A)1. and 2. above.

(C) All reports, plans, and specifications must be submitted at least one hundred eighty (180) calendar days prior to the date upon which action by the department is desired, or in accordance with a National Pollutant Discharge Elimination System (NPDES) permit or other departmental schedules. The documents, at the appropriate times, must be submitted for formal approval and should include the engineer's report or facility plan, design drawings, and specifications. Engineering reports or facility plans must be approved by the department prior to the submittal of the design drawings, specifications, and the appropriate permit applications and fees. For projects involving both collection systems and wastewater treatment facilities, the information required in subsection (4)(B) must be included in the facility plan. These documents are used by the owner in programming future action, by the department to evaluate probable compliance with statutes and regulations, and by bond attorneys and investment houses to develop and evaluate financing. Engineering reports and facility plans should broadly describe existing problems; consider methods for alternate solutions including site and/or route selection; estimate capital and annual costs; and outline steps for further project implementation, including financing and approval by the department and other agencies. No approval for construction can be issued until final detailed plans and specifications with the design engineer's imprint of his/her registration seal with the date and engineer's signature affixed have been submitted and found to be satisfactory by the department.

(D) Engineering reports and facility plans shall include a statement identifying the continuing authority, a contact person for the authority, and the continuing authority phone number and address, along with the design engineer's imprint of his/her registration seal with the date and engineer's signature affixed to the document.

(4) Engineering Report or Facility Plan.

(A) General.

1. The engineering report or facility plan identifies and evaluates wastewater related problems; assembles basic information; presents criteria and assumptions; examines alternate projects, with preliminary layouts and cost estimates; describes financing methods; sets forth anticipated charges for users; reviews organizational and staffing requirements; offers a conclusion with a proposed project for client consideration; and outlines official actions and procedures to implement the project. The planning document must include sufficient detail to demonstrate that the proposed project meets applicable criteria.

2. The overall plan, including process description and sizing, factual data, and controlling assumptions and considerations for the functional planning of wastewater facilities, is presented for each process unit and for the whole system. These data form the continuing technical basis for the detailed design and preparation of construction plans and specifications.

3. Architectural, structural, mechanical, and electrical designs are usually excluded. Sketches may be desirable to aid in presentation of a project. Outline specifications of process units, special equipment, etc., are occasionally included.

4. Engineering reports must be completed for projects involving gravity sewers, pressure sewer systems, wastewater pumping stations, and force mains. Facility plans must be completed for projects involving wastewater treatment facility projects and projects receiving funding through the grant and loan programs under 10 CSR 20-4.

A. Unless required by the department, an engineering report will not have to be submitted for projects limited to only eight-inch (8") (20 cm) gravity sewer extensions.

(B) Engineering Reports. Engineering reports shall contain the following information and other pertinent information as required by the department:

1. Problem defined. Description of the existing system must include an evaluation of the conditions and problems needing correction;

2. Flow loads. The existing and design average and peak flows and waste load must be established. The basis of the projection of initial and future flows and waste load must be included and must reflect the existing, or initial service area, and the anticipated future service area. Flow loading information and data needed for new facilities are included in paragraph (4)(C)4. of this rule;

3. Impact on existing wastewater facilities. The impact of the proposed project on all existing wastewater facilities, including gravity sewers, pump stations, and treatment facilities, must be evaluated. Refer to 10 CSR 20-8.120 and 10 CSR 20-8.130;

4. Project description. A written description of the project is required;

5. Drawings. Drawings or sketches identifying the site of the project and anticipated location and alignment of proposed facilities are required;

6. Technical information and design criteria. All technical and design information used to design the collection system(s), pump station(s), etc., must be provided either in the engineering report or in the summary of design and shall include, at a minimum, design tabulation flow, size, and velocities; all pump station calculations including energy requirements; special appurtenances; stream crossings; and system map (report size). Outline unusual specifications, construction materials, and construction methods; maps, photographs, and diagrams; and other supporting data needed to describe the system. If an engineering report is not required, this information must be included in the summary of design. Refer to 10 CSR 20-8.110(5);

7. Site information. Project site information should include topography, soils, geologic conditions, depth to bedrock, groundwater level, floodway or floodplain considerations, distance to water supply structures, roads, residences, and other pertinent site information; and

8. It is preferred that any request for a deviation from 10 CSR 20-8 be addressed along with the engineering justifications in the engineering report. Otherwise, all requests for deviations from 10 CSR 20-8.120 and 10 CSR 20-8.130 must accompany the plans and specifications.

(C) Facility Plans. Facility plans shall contain the following and other pertinent information as required by the department:

1. Problem evaluation and existing facility review—

A. Descriptions of existing system,

including condition and evaluation of problems needing correction; and

B. Summary of existing and previous local and regional wastewater facility and related planning documents, if applicable;

2. Planning and service area. Drawings identifying the planning area, the existing and potential future service area, the site of the project, and anticipated location and alignment of proposed facilities are required;

3. Population projection and planning period. Present and predicted population shall be based on a twenty (20)-year planning period. Phased construction of wastewater facilities shall be considered in rapid growth areas. Sewers and other facilities with a design life in excess of twenty (20) years shall be designed for the extended period;

4. Hydraulic capacity.

A. Flow definitions and identification. The following flows for the design year shall be identified and used as a basis for design for sewers, pump stations, wastewater treatment facilities, treatment units, and other wastewater handling facilities. Where any of the terms defined in this section are used in these design standards, the definition contained in this section applies.

(I) Design average flow—The design average flow is the average of the daily volumes to be received for a continuous twelve (12)-month period expressed as a volume per unit time. However, the design average flow for facilities having critical seasonal high hydraulic loading periods (e.g., recreational areas, campuses, and industrial facilities) shall be based on the daily average flow during the seasonal period.

(II) Design maximum daily flow—The design maximum daily flow is the largest volume of flow to be received during a continuous twenty-four (24)-hour period expressed as a volume per unit time.

(III) Design peak hourly flow—The design peak hourly flow is the largest volume of flow to be received during a one (1)-hour period expressed as a volume per unit time.

(IV) Design peak instantaneous flow—The design peak instantaneous flow is the instantaneous maximum flow rate to be received.

B. Hydraulic capacity for existing collection and treatment systems.

(I) Projections shall be made from actual flow data to the extent possible.

(II) The probable degree of accuracy of data and projections shall be evaluated. This reliability estimation shall include an evaluation of the accuracy of existing data, based on no less than one (1) year of data, as well as an evaluation of the reliability of estimates of flow reduction anticipated due to infiltration/inflow (I/I) reduction or flow increases due to elimination of sewer overflows and backups.

(III) Critical data and methodology used shall be included. Graphical displays of critical peak wet weather flow data (refer to parts (4)(C)4.A.(II), (III), and (IV) of this rule) shall be included for a sustained wet weather flow period of significance to the project.

C. Hydraulic capacity for new collection and treatment systems.

(I) The sizing of wastewater facilities receiving flows from new wastewater collection systems shall be based on an average daily flow of one hundred (100) gallons (0.38 m^3) per capita per day plus wastewater flow from industrial facilities and major institutional and commercial facilities unless water use data or other justification upon which to better estimate flow is provided.

(II) The one hundred (100) gallons (0.38 m^3) per capita per day figure shall be used, which, in conjunction with a peaking factor from the following Figure 1, included herein, is intended to cover normal infiltration for systems built with modern construction techniques. Refer to 10 CSR 20-8.120.

Schedule JAM-5

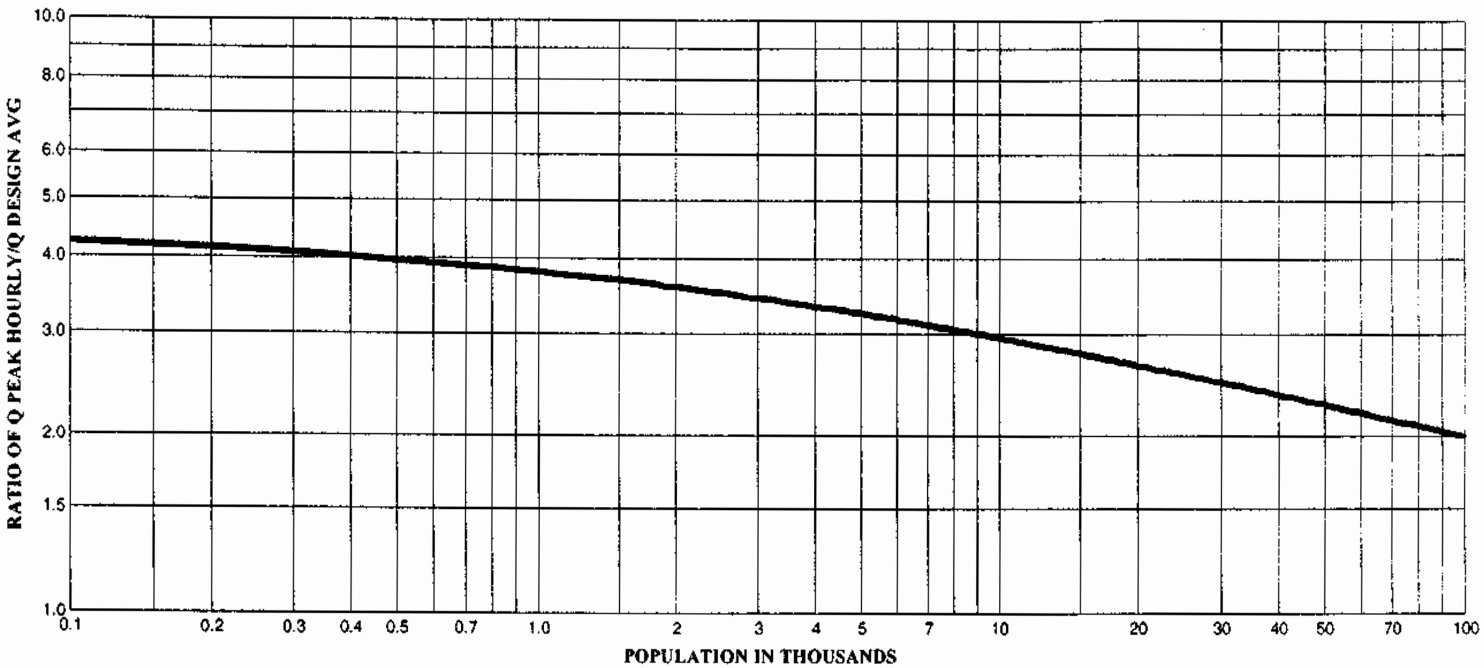

Figure 1. Ratio of peak hourly flow to design average flow.

where

Q peak hourly = Maximum Rate of Wastewater Flow (Peak Hourly Flow)

Q design avg = Design Average Daily Wastewater Flow

Equation: Q Peak Hourly/Q Design Avg $= \dfrac{18 + \sqrt{P}}{4 + \sqrt{P}}$

where

P = population in thousands

(III) If the new collection system is to serve existing development, the likelihood of infiltration/inflow (I/I) contributions from existing service lines and non-wastewater connections to those service lines shall be evaluated and wastewater facilities designed accordingly.

D. Combined sewer interceptors. In addition to the above requirements, interceptors for combined sewers shall have capacity to receive sufficient quantity of combined wastewater for transport to treatment facilities to ensure attainment of the appropriate water quality standards;

5. Organic capacity.

A. Organic load definitions and identification. The following organic loads for the design year shall be identified and used as a basis for design of wastewater treatment facilities. Where any of the terms defined in this section are used in these design standards, the definition contained in this section applies.

(I) Biochemical Oxygen Demand—The five (5)-day Biochemical Oxygen Demand (BOD_5) is defined as the amount of oxygen required to stabilize biodegradable organic matter under aerobic conditions within a five (5)-day period.

(a) Total five (5)-day Biochemical Oxygen Demand ($TBOD_5$) is equivalent to BOD_5 and is sometimes used in order to differentiate carbonaceous plus nitrogenous oxygen demand from strictly carbonaceous oxygen demand.

(b) The carbonaceous five (5)-day Biochemical Oxygen Demand ($CBOD_5$) is defined as BOD_5 less the nitrogenous oxygen demand of the wastewater.

(II) Design average BOD_5—The design average BOD_5 is generally the average of the organic load received for a continuous twelve (12)-month period for the design year expressed as weight per day. However, the design average BOD_5 for facilities having critical seasonal high loading periods (e.g., recreational areas, campuses, and industrial facilities) shall be based on the daily average BOD_5 during the seasonal period.

(III) Design maximum day BOD_5—The design maximum day BOD_5 is the largest amount of organic load to be received during a continuous twenty-four (24)-hour period expressed as weight per day.

(IV) Design peak hourly BOD_5—The design peak hourly BOD_5 is the largest amount of organic load to be received during a one (1)-hour period expressed as weight per day.

B. Design of organic capacity of wastewater treatment facilities to serve existing collection systems.

(I) Projections shall be made from actual wasteload data to the extent possible.

(II) Projections shall be compared to subparagraph (4)(C)5.C. of this rule and an accounting made for significant variations from those values.

(III) Impact of industrial sources shall be documented.

C. Organic capacity of wastewater treatment facilities to serve new collection systems.

(I) Domestic wastewater treatment design shall be on the basis of at least 0.17 pounds (0.08 kg) of BOD_5 per capita per day and 0.20 pounds (0.09 kg) of suspended solids per capita per day, unless information is submitted to justify alternate designs.

(II) Impact of industrial sources shall be documented.

(III) Data from similar municipalities may be utilized in the case of new systems. However, thorough investigation that is adequately documented shall be provided to the department to establish the reliability and applicability of such data;

6. Wastewater treatment facility design capacity. The wastewater treatment facility design capacity is the design average flow at the design average BOD_5. Refer to paragraphs (4)(C)4. and (4)(C)5. of this rule for peaking factors that will be required.

A. Engineering criteria. Engineering criteria and assumptions used in the design of the project shall be provided in the facility plan. Refer to subsection (4)(D) of this rule for additional information.

B. If the project includes the land application of wastewater, the requirements in 10 CSR 20-8.220 must be included with the facility plan;

7. Initial alternative development. For projects receiving funding through the grant and loan programs in 10 CSR 20-4, the process of selection of wastewater treatment and collection system alternatives for detailed evaluation shall be discussed. All wastewater management alternatives considered and the basis for the engineering judgment for selection of the alternatives chosen for detailed evaluation shall be included;

8. Detailed alternative evaluation. The following shall be included for the alternatives to be evaluated in detail.

A. Sewer system revisions. Proposed revisions to the existing sewer system including adequacy of portions not being changed by the project.

B. Wet weather flows. Facilities to transport and treat wet weather flows in a manner that complies with state and local regulations must be provided. The design of wastewater treatment facilities and sewers shall provide for transportation and treatment of all flows including wet weather flows unless the owner's National Pollutant Discharge Elimination System (NPDES) permit authorizes a bypass.

C. Site evaluation. When a site must be used which is critical with respect to these items, appropriate measures shall be taken to minimize adverse impacts.

(I) Compatibility of the treatment process with the present and planned future land use, including noise, potential odors, air quality, and anticipated sludge processing and disposal techniques, shall be considered. Non-aerated lagoons should not be used if excessive sulfate is present in the wastewater. Wastewater treatment facilities should be separate from habitation or any area likely to be built up within a reasonable future period and shall be separated in accordance with state and local requirements.

(II) Zoning and other land use restrictions shall be identified.

(III) An evaluation of the accessibility and topography of the site shall be submitted.

(IV) Area for future plant expansion shall be identified.

(V) Direction of prevailing wind shall be identified.

(VI) Flood considerations, including the twenty-five (25)-year and one hundred (100)-year flood levels, impact on floodplain and floodway, and compliance with applicable regulations in 10 CSR 20-8 regarding construction in flood-prone areas, shall be evaluated.

(VII) Geologic information, depth to bedrock, karst features, or other geologic considerations of significance to the project shall be included. A copy of a geological site evaluation from the department's Division of Geology and Land Survey providing stream determinations (gaining or losing) must be included for all new wastewater treatment facilities. A copy of a geological site evaluation providing site collapse and overall potentials from the department's Division of Geology and Land Survey must be included for all earthen basin structures. Earthen basin structures shall not be located in areas receiving a severe overall geological collapse potential rating.

(VIII) Protection of groundwater including public and private wells is of utmost importance. Demonstration that protection will be provided must be included. If the proposed wastewater facilities will be near a water source or other water facility, as determined by the department's Division of

Schedule JAM-5

Geology and Land Survey or by the department's Public Drinking Water Branch addressing the allowable distance between these wastewater facilities and the water source must be included with the facility plan. Refer to 10 CSR 20-8.130 and 10 CSR 20-8.140.

(IX) Soil type and suitability for construction and depth to normal and seasonal high groundwater shall be determined.

(X) The location, depth, and discharge point of any field tile in the immediate area of the proposed site shall be identified.

(XI) Present and known future effluent quality and monitoring requirements determined by the department shall be included. Refer to subparagraph (4)(C)8.N. of this rule.

(XII) Access to receiving stream for the outfall line shall be discussed and displayed.

(XIII) A preliminary assessment of site availability shall be included.

D. Unit sizing. Unit operation and preliminary unit process sizing and basis shall be discussed.

E. Flow diagram. A preliminary flow diagram of treatment facilities including all recycle flows shall be provided.

F. Emergency operation. Emergency operation requirements as outlined in 10 CSR 20-8.130 and 10 CSR 20-8.140 shall be discussed and provided.

G. The no-discharge option must be examined and included as an alternative in the facility plan.

H. Technology not included in these standards. 10 CSR 20-8.140 outlines procedures for introducing and obtaining approval to use technology not included in these standards. Proposals to use technology not included in these standards must address the requirements of 10 CSR 20-8.140.

I. Biosolids. The solids disposal options considered and method selected must be included. This is critical to completion of a successful project. Compliance with requirements of 10 CSR 20-8.170 and any conditions in the owner's National Pollutant Discharge Elimination System (NPDES) permit must be assured.

J. Treatment during construction. A plan for the method and level of treatment to be achieved during construction shall be developed and included in the facility plan that must be submitted to the department for review and approval. This approved treatment plan must be implemented by inclusion in the plans and specifications to be bid for the project. Refer to paragraph (6)(A)5. and subsection (7)(D) of this rule.

K. Operation and maintenance. Portions of the project which involve complex operation or maintenance requirements shall be identified, including laboratory requirements for operation, industrial sampling, and self monitoring.

L. Cost estimates. Cost estimates for capital and operation and maintenance (including basis) must be included for projects receiving funding through the grant and loan programs in 10 CSR 20-4.

M. Environmental review.

(I) Compliance with planning requirements of local government agencies must be documented.

(II) Any additional environmental information meeting the criteria in 10 CSR 20-4.050, for projects receiving funding through the state grant and loan programs.

N. Water quality reports. Include all reviews, studies, or reports required by 10 CSR 20-7, Water Quality, and approved by the department. Any information or sections in an approved study or report required by 10 CSR 20-7 that addresses the requirements in subsection (4)(C) of this rule can be incorporated into the facility plan in place of these sections;

9. Final project selection. The project selected from the alternatives considered under paragraph (4)(C)10. of this rule shall be set forth in the final facility plan document to be forwarded to the department for review and approval, including the financing considerations and recommendations for implementation of the plan; and

10. It is preferred that any request for a deviation from 10 CSR 20-8 be addressed along with the engineering justifications in the facility plan. Otherwise, all requests for deviations along with the engineering justification from 10 CSR 20-8.120 through 10 CSR 20-8.220 must accompany the plans and specifications.

(D) Appendices. Technical Information and Design Criteria. Due to the complexity of wastewater facilities or funding issues, the following information shall be included upon the request of the department. All system design information can be submitted as, and for all review purposes will be considered, preliminary design data.

1. Process facilities. Criteria selection and basis; hydraulic and organic loadings—minimum, average, maximum, and effect (wastewater and sludge processes); unit dimensions; rates and velocities; detentions concentrations; recycle; chemical additive control; physical control and flow metering; removals; effluent concentrations, etc. (include a separate tabulation for each unit to handle solid and liquid fractions); energy requirement; and flexibility.

2. Process diagrams. Process configuration, interconnecting piping, processing, flexibility; hydraulic profile; organic loading profile; solids profile; solids control system; and flow diagram with capacities, etc.

3. Laboratory. Physical and chemical tests and frequency to control process; time for testing; space and equipment requirements; and personnel requirements—number, type, qualifications, salaries, benefits (tabulate), and a brief description of the laboratory facility. See 10 CSR 20-8.140.

4. Operation and maintenance. Routine special maintenance duties; time requirements; tools, spare parts, equipment, vehicles, safety; maintenance workspace and storage; and personnel requirements—number, type, qualifications, training, salaries, benefits (tabulate).

5. Chemical control. Processes needing chemical addition; chemicals and feed equipment; tabulation of amounts and unit and total costs.

6. Collection systems control. Cleaning and maintenance; regulator and overflow inspection and repair; flow gauging; industrial sampling and surveillance; ordinance enforcement; equipment requirements; trouble-call investigation; and personnel requirements—number, type, qualifications, salaries, benefits, training (tabulate).

7. Control summary. Personnel; equipment; chemicals, utilities, list power requirements of major units; and summation.

(5) Summary of Design. A summary of design shall accompany the plans and specifications and shall include the following:

(A) Flow and waste projections including design and peak hydraulic and organic loadings shall be provided for sewers, pump stations, and wastewater treatment facilities. Information shall be submitted to verify adequate downstream capacity of sewers, pump stations, and wastewater treatment and sludge handling unit(s);

(B) Type and size of individual process units including unit dimensions; rates and velocities; detention times; concentrations; recycle; chemical additive control; physical control, flexibility, and flow metering;

(C) Show process diagrams, including flow diagrams with capacities;

(D) Expected removal rates and concentrations of permitted effluent parameters in the discharge from the wastewater treatment facility, including a separate tabulation for each unit to handle solid and liquid fractions;

(E) Design calculations, tabulations, assumptions, and deviations from 10 CSR 20-8.120 through 10 CSR 20-8.220 used in the design of the system(s);

(F) Include unusual specifications, construction materials, and construction methods; maps, photographs, diagrams; and other support data needed to describe the system; and

(G) Unless required in 10 CSR 20-8.120 through 10 CSR 20-8.220, specific design calculations for the architectural, structural, and mechanical components of a system do not have to be included with the design criteria.

(6) Plans.

(A) General.

1. One (1) set of drawings shall be submitted to the department for review. In addition to the set of drawings, an electronic version of the plans can be submitted to assist in the review. Additional sets of drawings may be required by the department for final approval.

2. Plan title. All plans for wastewater facilities shall bear a suitable title showing the name of the municipality, sewer district, or institution; and shall show the scale in feet, a graphical scale, the north point, date, and the name of the engineer, certificate number, and imprint of his/her registration seal with the engineer's signature.

3. Plan format. The plans shall be clear and legible (suitable for microfilming or scanning). They shall be drawn to scale, which will permit all necessary information to be plainly shown for review and suitable for the contracting and construction of the facilities.

A. To allow for microfilming or scanning, plans must not be smaller than twenty-four inches by thirty-six inches (24" × 36") (61 cm x 91 cm) or larger than thirty-six inches by forty-eight inches (36" × 48") (91.4 cm × 122 cm). Datum used shall be indicated. Locations and logs of test borings, when required, shall be shown on the plans. Test boring logs must be included on the plans or in the specifications as an appendix. Blueprints shall not be submitted.

4. Plan contents. Detail plans shall consist of—plan views, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the facilities. They shall also include dimensions and relative elevations of structures, the location and outline form of equipment, location and size of piping, water levels, and ground elevations.

5. Operation during construction. Project construction documents shall specify the procedure for operation during construction that complies with the plan required by subparagraph (4)(C)8.J. and subsection (7)(D) of this rule.

(B) Plans of Sewers.

1. General plan. A plan of existing and proposed sewers shall be submitted for projects involving new sewer systems and substantial additions to existing systems. This plan shall show the following:

A. Geographical features.

(I) Topography and elevations. Existing or proposed streets and all streams or water surfaces shall be clearly shown. Contour lines at suitable intervals should be included.

(II) Streams. The direction of flow in all streams and high and low water elevations of all water surfaces and overflows shall be shown.

(III) Boundaries. The boundary lines of the municipality or the sewer district and the area to be sewered shall be shown; and

B. Sewers. The plan shall show the location, size, and direction of flow of all existing and proposed sanitary and combined sewers draining to the treatment facility concerned.

2. Detail plans. Detail plans shall be submitted. Profiles shall have a horizontal scale of not more than one hundred feet (100') to the inch (12 m to the cm) and a vertical scale of not more than ten feet (10') to the inch (1.2 m to the cm). Plan views should be drawn to a corresponding horizontal scale and must be shown on the same sheet. Plans and profiles shall show—

A. Location of streets and sewers;

B. Line of ground surface, pipe size, length between manholes, invert and surface elevation at each manhole, grade of sewer between each two (2) adjacent manholes, pipe material and type, and where special construction features are required. All manholes shall be numbered on the plan and correspondingly numbered on the profile;

C. Where there is any question of the sewer being sufficiently deep to serve any residence, the elevation and location of the basement floor shall be plotted on the profile of the sewer which is to serve the house in question. The engineer shall state that all sewers are sufficiently deep to serve adjacent basements except where otherwise noted on the plans;

D. Locations of all special features such as inverted siphons, concrete encasements, elevated sewers, etc.;

E. All known existing structures and utilities both above and below ground, which might interfere with the proposed construction or require isolation setback, particularly water mains and water supply structures (i.e., wells, clear wells, basins, etc.), gas mains, storm drains, and telephone, cable, and power conduits; and

F. Special detail drawings, made to a scale to clearly show the nature of the design, shall be furnished to show the following particulars:

(I) All stream crossings with elevations of the stream bed and high, normal, and low water levels; and

(II) Details of all special sewer joints and cross-sections; details of all sewer appurtenances such as manholes, lampholes, inspection chambers, inverted siphons, regulators, tide gates, and elevated sewers.

(C) Plans of Wastewater Pumping Stations.

1. Location plan. A plan shall be submitted for projects involving construction or revision of pumping stations. This plan shall show the following: the location and extent of the tributary area; any municipal boundaries with the tributary area; the location of the pumping station and force main; and pertinent elevations.

2. Detail plans. Detail plans shall be submitted showing the following, where applicable:

A. Topography of the site;

B. Existing pumping station;

C. Proposed pumping station, including provisions for installation of future pumps;

D. Elevation of high water at the site and maximum elevation of wastewater in the collection system upon occasion of power failure;

E. Maximum hydraulic gradient in downstream gravity sewers when all installed pumps are in operation; and

F. Test boring and groundwater elevations.

(D) Plans of Wastewater Treatment Plants.

1. Location plan.

A. A plan shall be submitted showing the wastewater treatment plant in relation to the remainder of the system.

B. Sufficient topographic features shall be included to indicate its location with relation to streams and the point of discharge of treated effluent.

2. General layout. Layouts of the proposed wastewater treatment plant shall be submitted showing—

A. Topography of the site;

B. Size and location of plant structures;

C. Schematic flow diagram(s) showing the flow through various plant units and showing utility systems serving the plant processes;

Schedule JAM-5

D. Piping, including any arrangement for bypassing individual units; materials handled and direction of flow through pipes shall be shown;

E. Hydraulic profiles showing the flow of wastewater, supernatant liquor, and sludge; and

F. Test borings and groundwater elevations shall be provided.

3. Detail plans. Detail plans shall show the following, unless otherwise covered by the specifications or facility plan:

A. Location, dimensions, and elevations of all existing and proposed plant facilities;

B. Elevations of high and low water level of the body of water to which the plant effluent is to be discharged;

C. Type, size, pertinent features, and operating capacity of all pumps, blowers, motors, and other mechanical devices;

D. Minimum, design average, and peak hourly hydraulic flow in profile; and

E. Adequate description of any other features pertinent to the design.

(7) Specifications.

(A) Complete signed, sealed, and dated technical specifications shall be submitted for the construction of sewers, wastewater pumping stations, wastewater treatment plants, and all other appurtenances. Technical specifications shall accompany the plans.

(B) The specifications accompanying construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the builder, in detail, of the design requirements for the quality of materials, workmanship, and fabrication of the project.

(C) The specifications shall also include: the type, size, strength, operating characteristics, and rating of equipment; allowable infiltration; the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping, and jointing of pipe; electrical apparatus, wiring, instrumentation, and meters; laboratory fixtures and equipment; operating tools; construction materials; special filter materials such as stone, sand, gravel, or slag; miscellaneous appurtenances; chemicals when used; instructions for testing materials and equipment as necessary to meet design standards; and performance tests for the completed facilities and component units. It is suggested that these performance tests be conducted at design load conditions wherever practical.

(D) Operation During Construction. Specifications shall contain a program for keeping existing wastewater treatment plant units in operation during construction of plant additions. Should it be necessary to take plant units out of operation, specifications shall include detailed construction requirements and schedules to avoid unacceptable temporary water quality degradation in accordance with subparagraph (4)(C)8.J. and paragraph (5)(A)5. of this rule.

(8) Revisions to Approved Plans. Any deviations from approved plans or specifications affecting capacity, flow, system layout, operation of units, or point of discharge shall be approved by the department in writing before such changes are made. Plans or specifications so revised should, therefore, be submitted well in advance of any construction work which will be affected by such changes, to permit sufficient time for review and approval. Structural revisions or other minor changes not affecting capacities, flows, or operation will be permitted during construction without approval. As built plans clearly showing the alterations shall be submitted to the department at the completion of the work.

AUTHORITY: section 644.026, RSMo 2000. Original rule filed Aug. 10, 1978, effective March 11, 1979. Amended: Filed Sept. 14, 2010, effective June 30, 2011.*

**Original authority: 644.026, RSMo 1972, amended 1973, 1987, 1993, 1995, 2000.*

10 CSR 20-8.120 Design of Gravity Sewers

PURPOSE: The following criteria have been prepared as a guide for the design of sewers. This rule is to be used with rules 10 CSR 20-8.110 through 10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission in regard to adequacy of design, submission of plans, approval of plans, and approval of completed wastewater treatment facilities and collection systems. It is not reasonable or practical to include all aspects of design in these standards. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of all ASTM International standards pertaining to sewers and appurtenances, design manuals such as Water Environment Federation's Manuals of Practice, and other sewer design manuals containing principles of accepted engineering practice. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from the 2004 edition of the Great Lakes-Upper Mississippi River Board of State and Provincial Public Health and Environmental Managers' ***Recommended Standards for Wastewater Facilities*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear.*

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms "shall" and "must" are used, they are to mean a mandatory requirement insofar as approval by the Missouri Department of Natural Resources (department) is concerned, unless justification is presented for deviation from the requirements. Other terms, such as "should," "recommend," "preferred," and the like, indicate the preference of the department for consideration by the design engineer.

(A) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(2) Applicability. This rule shall apply to all facilities with a design flow of one hundred thousand (100,000) gallons (378.5 m^3) per day or greater. This rule shall also apply to all facilities with a design flow of twenty-two thousand five hundred (22,500) gallons (85.2 m^3) per day or greater until such time as 10 CSR 20-8.020 is amended.

(3) Approval of Sewers. The department will approve plans for new systems, extensions to new areas, or replacement sanitary sewers only when designed upon the separate basis, in which rainwater from roofs, streets, and other areas and groundwater from foundation drains are excluded.

(4) Design Capacity and Design Flow.

(A) Sewer capacities shall be designed for the estimated ultimate tributary population, except in considering parts of the systems that can be readily increased in capacity. Similarly, consideration must be given to the maximum anticipated capacity of institutions, industrial parks, etc. An economic analysis of alternatives must be included in the engineering report or facility plan where future relief sewers are planned.

1. The following factors must be considered in determining the required capacities of sanitary sewers:

A. Design peak hourly flow;

B. Additional maximum wastewater or waste flow from industrial plants;

C. Inflow and infiltration (I/I);

D. Topography of area;

E. Location of wastewater treatment facilities;

F. Depth of excavation; and

G. Pumping requirements.

2. The basis of design for all sewer projects shall be included in the engineering report or facility plan. More detailed computations may be required by the department for critical projects.

(B) Sewer flows shall be based on the design peak hourly flow in accordance with 10 CSR 20-8.110(4)(C)4. and must be designed to prevent or eliminate sanitary sewer overflows (SSOs).

(5) Details of Design and Construction.

(A) Minimum Size. Gravity sewers conveying raw wastewater shall be no less than eight inches (8") (20 cm) in diameter, except in circumstances where smaller diameter pipe can be justified.

(B) Depth. All sewers shall be sufficiently deep so as to receive wastewater from basements and shall be covered with at least thirty-six inches (36") (91 cm) of soil, other insulation, or material to prevent freezing and to protect them from superimposed loads.

(C) Buoyancy. Buoyancy of sewers shall be considered and flotation of the pipe shall be prevented with appropriate construction where high groundwater conditions are anticipated.

(D) Slope.

1. All sewers shall be designed and constructed to give mean velocities, when flowing full, of not less than two feet (2') per second (0.6 m/s). The following are the minimum slopes which should be provided for sewers forty-two inches (42") (107 cm) or less; however, slopes greater than these may be desirable for construction, to control sewer gases, or to maintain self-cleansing velocities at all rates of flow within the design limits:

Nominal Sewer Size	Minimum Slope in Feet Per 100 Feet (m/100 m)
8 inch (20 cm)	0.40
10 inch (25 cm)	0.28
12 inch (30 cm)	0.22
14 inch (36 cm)	0.17
15 inch (38 cm)	0.15
16 inch (41 cm)	0.14
18 inch (46 cm)	0.12
21 inch (53 cm)	0.10
24 inch (61 cm)	0.08
27 inch (69 cm)	0.067
30 inch (76 cm)	0.058
33 inch (84 cm)	0.052
36 inch (91 cm)	0.046
39 inch (99 cm)	0.041
42 inch (107 cm)	0.037

A. Sewer sizes not included in the above table should be designed and constructed to give mean velocities, when flowing full, of not less than three feet (3') per second (0.9 m/s), based on Manning's formula using an "n" value of 0.013.

2. Minimum flow depths. Slopes which are slightly less than the recommended minimum slopes may be permitted. Such decreased slopes may be considered where the depth of flow will be one-third (1/3) of the diameter or greater for design average flow. Whenever decreased slopes are selected, the design engineer must furnish with his/her engineering report or facility plan computations of the anticipated flow velocities of average daily and peak hourly flow rates. The operating authority of the sewer system will give written assurance to the department that any additional sewer maintenance required by reduced slopes will be provided.

3. Minimize solids deposition. The pipe diameter and slope shall be selected to obtain the greatest practical velocities to minimize settling problems. Oversize sewers will not be approved to justify using flatter slopes. If the proposed slope is less than the minimum slope of the smallest pipe, which can accommodate the design peak hourly flow, the actual depths and velocities at minimum, average, and design maximum day and peak hourly flow for each design section of the sewer shall be calculated by the design engineer and be included with the plans.

4. Slope between manholes. Sewers shall be laid with uniform slope between manholes.

5. High velocity protection. Where velocities greater than fifteen feet (15') per second (4.6 m/s) are attained, special provision shall be made to protect against displacement by erosion and impact.

6. Steep slope protection. Sewers on twenty percent (20%) slope or greater shall be anchored securely with concrete anchors or equal, spaced as follows:

A. Not over thirty-six feet (36') (11 m) center-to-center on grades twenty percent (20%) and up to thirty-five percent (35%);

B. Not over twenty-four feet (24') (7.3 m) center-to-center on grades thirty-five percent (35%) and up to fifty percent (50%); and

C. Not over sixteen feet (16') (4.9 m) center-to-center on grades fifty percent (50%) and over.

(E) Alignment.

1. Sewers twenty-four inches (24") (61 cm) or less shall be laid with straight alignment between manholes. Straight alignment shall be checked by either using a laser beam or lamping.

2. Curvilinear alignment of sewers larger than twenty-four inches (24") (61 cm) may be considered on a case-by-case basis provided compression joints are specified and ASTM or specific pipe manufacturers' maximum allowable pipe joint deflection limits are not exceeded. Curvilinear sewers shall be limited to simple curves which start and end at manholes. When curvilinear sewers are proposed, the recommended minimum slopes indicated in paragraph (5)(D)1. of this rule must be increased accordingly to provide a minimum velocity of two feet (2') per second (0.6 m/s) when flowing full.

(F) Changes in Pipe Size.

1. When a smaller sewer joins a larger one, a manhole is required according to subparagraph (6)(A)1.B. of this rule. The invert of the larger sewer should be lowered sufficiently to maintain the same energy gradient. An approximate method for securing these results is to place the 0.8 depth point of both sewers at the same elevation.

2. Sewer extensions should be designed for projected flows. When the diameter of the receiving sewer is less than the diameter of the proposed extension at a manhole, the manhole shall be constructed with special consideration of an appropriate flow channel to minimize turbulence. The department may require a schedule for construction of future downstream sewer relief.

(G) Materials. Any generally accepted material for sewers will be given consideration, but the material selected should be adapted to local conditions, such as character of industrial wastes, possibility of septicity,

Schedule JAM-5

soil characteristics, exceptionally heavy external loadings, abrasion, corrosion, and similar problems.

1. All sewer pipe and joint materials shall conform to the appropriate ASTM specifications.

2. Suitable couplings complying with ASTM specifications shall be used for joining dissimilar materials. The leakage limitations on these joints shall be in accordance with paragraph (5)(I)4. or (5)(I)5. of this rule.

3. All sewers shall be designed to prevent damage from superimposed live, dead, and frost-induced loads. Proper allowance for loads on the sewer shall be made because of soil and potential groundwater conditions, as well as the width and depth of the trench. Where necessary, special bedding, haunching, initial backfill, concrete cradle, or other special construction shall be used to withstand anticipated potential superimposed loading or loss of trench wall stability. See ASTM D2321 or ASTM C12 when appropriate.

4. For new pipe or joint materials for which ASTM standards have not been established, the design engineer shall provide complete material and installation specifications developed on the basis of criteria adequately documented and certified in writing by the pipe manufacturer to be satisfactory for the specific detailed plans for approval by the department.

(H) Installation.

1. Standards. Installation specifications shall contain appropriate requirements based on the criteria, standards, and requirements established by industry in its technical publications. Requirements shall be set forth in the specifications for the pipe and methods of bedding and backfilling thereof so as not to damage the pipe or its joints, impede cleaning operations, and future tapping, nor create excessive side fill pressures and ovalation of the pipe, nor seriously impair flow capacity.

2. Trenching.

A. The width of the trench shall be ample to allow the pipe to be laid and jointed properly and to allow the bedding and haunching to be placed and compacted to adequately support the pipe. The trench sides shall be kept as nearly vertical as possible. When wider trenches are specified, appropriate bedding class and pipe strength shall be used.

B. In unsupported and unstable soil, the size and stiffness of the pipe, stiffness of the embedment, insitu soil, and depth of cover shall be considered in determining the minimum trench width necessary to adequately support the pipe.

C. Ledge rock, boulders, and large stones shall be removed to provide a minimum clearance of four inches (4") (10 cm) below and on each side of all pipe(s).

D. Dewatering. All water entering the excavations or other parts of the work shall be removed until all the work has been completed. No sanitary sewer that ultimately arrives at existing pumping stations or wastewater treatment facilities shall be used for the disposal of trench water.

3. Bedding, haunching, and initial backfill.

A. Rigid pipe. Bedding Classes A, B, C, or crushed stone, as described in ASTM C12, shall be used and carefully compacted for all rigid pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

B. Ductile iron pipe. Embedment materials for bedding and initial backfill, as described in ASTM A746 for Type 1 through Type 5 laying conditions, shall be used for ductile iron pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

C. Plastic pipe. Embedment materials for bedding, haunching, and initial backfill, Classes I, II, or III, as described in ASTM D2321, shall be used and carefully compacted for all flexible pipe provided the proper strength pipe is used with the specified bedding to support the anticipated load based on the type of soil encountered and potential groundwater conditions.

D. Composite pipe. Except as described in ASTM D2680, the bedding, haunching, and initial backfill requirements for composite pipe shall be the same as for plastic pipe.

4. Final backfill.

A. Final backfill shall be of a suitable material removed from excavation except where other material is specified. Debris, frozen material, large clods, stones, organic matter, or other unstable materials shall not be used for final backfill within two feet (2') (0.6 m) of the top of the pipe.

B. Final backfill shall be placed in such a manner as not to disturb the alignment of the pipe.

5. Deflection test.

A. Deflection tests shall be performed on all flexible pipe. The test shall be conducted after the final backfill has been in place at least thirty (30) days to permit stabilization of the soil-pipe system.

B. No pipe shall extend a deflection of five percent (5%). If the deflection exceeds five percent (5%), the pipe shall be excavated. Replacement or correction shall be accomplished in accordance with requirements in the department-approved specifications.

C. The rigid ball or mandrel used for the deflection test shall have a diameter not less than ninety-five percent (95%) of the base inside diameter or average inside diameter of the pipe depending on which is specified in the ASTM specification, including the appendix, to which the pipe is manufactured. The test shall be performed without mechanical pulling devices. A mandrel must have nine (9) or more odd number of flutes or points.

6. Video inspection. Video inspection of all new and rehabilitated sewers after installation is recommended.

(I) Joints and Infiltration.

1. Joints. The installation of joints and the materials used shall be included in the specifications. Sewer joints shall be designed to minimize infiltration and to prevent the entrance of roots throughout the life of the system.

2. Service connections. Service connections to the sewer main shall be watertight and not protrude into the sewer. If a saddle-type connection is used, it shall be a device designed to join with the types of pipe which are to be connected. All materials used to make service connections shall be compatible with each other and with the pipe materials to be joined and shall be corrosion proof.

3. Leakage tests. Leakage tests shall be specified. This may include appropriate water or low pressure air testing. The testing methods selected should take into consideration the range in groundwater elevations during the test and anticipated during the design life of the sewer.

4. Water (hydrostatic) test. The leakage exfiltration or infiltration shall not exceed one hundred (100) gallons per inch of pipe diameter per mile per day (0.38 m^3/cm of pipe diameter/km/day) for any section between manholes of the system. An exfiltration or infiltration test shall be performed with a minimum positive head of two feet (2') (0.6 m).

5. Air test. The air test shall, as a minimum, conform to the test procedure described in ASTM C828 for clay pipe, ASTM C924 for concrete pipe twenty-four inches (24") or less in diameter, ASTM C1103 for concrete pipe twenty-seven inches (27") or greater in diameter, and ASTM F1417 for plastic, composite, and ductile iron pipe. All other materials shall have test procedures approved by the department.

(J) Alternative Installation Methods

(Trenchless Technologies). Trenchless technologies shall be evaluated by the department on a case-by-case basis.

(6) Manholes.

(A) Location.

1. Manholes shall be installed—

A. At the end of each line;

B. At all changes in grade, size, or alignment;

C. At all sewer pipe intersections;

D. At distances not greater than four hundred feet (400') (120 m) for sewers fifteen inches (15") (38 cm) or less; and

E. At distances not greater than five hundred feet (500') (150 m) for sewers sixteen inches to thirty inches (16"–30") (46 cm–76 cm).

2. Spacing of manholes greater than five hundred feet (500') (150 m) may be approved by the department in cases where adequate cleaning equipment can justify such spacing.

3. Greater spacing may be permitted in larger sewers.

4. Cleanouts may be used only for special conditions and shall not be substituted for manholes nor installed at the end of laterals greater than one hundred fifty feet (150') (46 m) in length.

(B) Drop Type.

1. A drop pipe shall be provided for a sewer entering a manhole at an elevation of twenty-four inches (24") (61 cm) or more above the manhole invert. Where the difference in elevation between the incoming sewer and the manhole invert is less than twenty-four inches (24") (61 cm), the invert shall be filleted to prevent solids deposition.

2. Drop manholes should be constructed with outside drop connection. Inside drop connections can be used when the manhole diameter is sufficient to secure the drop pipe to the interior wall of the manhole and provide adequate access for cleaning.

3. When using precast manholes, drop connections must not enter the manhole at a joint.

4. Due to the unequal earth pressures that would result from the backfilling operation in the vicinity of the manhole, the entire outside drop connection shall be encased in concrete.

(C) Diameter. The minimum diameter of manholes shall be forty-two inches (42") (107 cm) on eight-inch (8") (20 cm) diameter gravity sewer lines and forty-eight inches (48") (122 cm) on all sewer lines larger than eight inches (8") (20 cm) in diameter. Larger diameter manholes are necessary for large diameter sewers in order to maintain structural integrity. A minimum access diameter of twenty-two inches (22") (56 cm) shall be provided.

(D) Flow Channel.

1. The flow channel straight through a manhole should be made to conform as closely as possible in shape and slope to that of the connecting sewers, without obstructing maintenance, inspection, or flow in the sewers.

2. When curved flow channels are specified in manholes, including branch inlets, minimum slopes indicated in paragraph (5)(D)1. of this rule should be increased to maintain acceptable velocities.

(E) Bench. A bench shall be provided on each side of any manhole channel when the pipe diameter(s) are less than the manhole diameter. The bench should be sloped no less than a one-half inch per foot (0.5 in/ft) (12.7 mm/m). No pipe shall discharge onto the surface of the bench.

(F) Watertightness.

1. Manholes shall be watertight. Manholes shall be of the precast concrete or poured-in-place concrete type. Precast manholes shall conform to the design and test methods specified in ASTM C478 and C497.

2. Manhole lift holes, grade adjustment rings, precast section joints, and any additional areas potentially subject to infiltration shall be sealed watertight.

3. Inlet and outlet pipes shall be joined to the manhole with a gasketed flexible watertight connection or any watertight connection arrangement that allows differential settlement of the pipe and manhole wall to take place.

4. Watertight manhole covers are to be used wherever the manhole tops may be flooded by street runoff or high water. Bolt-down cover assemblies may be needed on manholes subject to displacement by sewer surcharging. Locked manhole covers may be desirable in isolated easement locations or where vandalism may be a problem.

(G) Inspection and Testing. The specifications shall include a requirement for inspection and testing for watertightness or damage prior to placing into service.

1. Vacuum testing, if specified for concrete sewer manholes, shall conform to the test procedures in ASTM C1244 or the manufacturer's recommendation.

2. Exfiltration testing, if specified for concrete sewer manholes, shall conform to the test procedures in ASTM C969.

(H) Corrosion Protection for Manholes. Where corrosive conditions due to septicity or other causes are anticipated, corrosion protection on the interior of the manholes shall be provided.

(I) Electrical. Electrical equipment installed or used in manholes shall conform to 10 CSR 20-8.130(4)(C)5.

(7) Inverted Siphons. Inverted siphons shall have not less than two (2) barrels, with a minimum pipe size of six inches (6") (15 cm). They shall be provided with necessary appurtenances for maintenance, convenient flushing, and cleaning equipment. The inlet and discharge structures shall have adequate clearances for cleaning equipment, inspection, and flushing. Design shall provide sufficient head and appropriate pipe sizes to secure velocities of at least three feet (3') per second (0.9 m/s) for design average flows. The inlet and outlet details shall be arranged so that the design average flow is diverted to one (1) barrel and so that either barrel may be cut out-of-service for cleaning. The vertical alignment should permit cleaning and maintenance.

(8) Sewers in Relation to Streams.

(A) Location of Sewers in Streams.

1. Cover depth. The top of all sewers entering or crossing streams shall be at a sufficient depth below the natural bottom of the stream bed to protect the sewer line. In general, the following cover requirements must be met:

A. One foot (1') (0.3 m) of cover is required where the sewer is located in rock;

B. Three feet (3') (0.9 m) of cover is required in other material. In major streams, more than three feet (3') (0.9 m) of cover may be required;

C. In paved stream channels, the top of the sewer line should be placed below the bottom of the channel pavement; and

D. Less cover will be approved only if the proposed sewer crossing will not interfere with future modifications to the stream channel. Justification for requesting less cover shall be provided to the department.

2. Horizontal location. Sewers along streams shall be located sufficiently outside the stream bed to prevent pollution by siltation during construction and to minimize possible exposure due to erosion.

3. Structures. The sewer outfalls, headwalls, manholes, gateboxes, or other structures shall be located so they do not interfere with the free discharge of flood flows of the stream.

4. Alignment. Sewers crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible and shall be free from change in grade.

5. Sewer systems shall be designed to minimize the number of stream crossings.

(B) Construction.

1. Materials. Sewers entering or crossing streams shall be constructed of ductile-iron pipe with mechanical joints; otherwise,

Schedule JAM-5

they shall be constructed so they will remain watertight and free from changes in alignment or grade. Material used to backfill the trench shall be stone, coarse aggregate, washed gravel, or other materials which will not readily erode, cause siltation, damage pipe during placement, or corrode the pipe.

2. Siltation and erosion. Construction methods that will minimize siltation and erosion shall be employed. The design engineer shall include in the project specifications the method(s) to be employed in the construction of sewers in or near streams. Such methods shall provide adequate control of siltation and erosion by limiting unnecessary excavation, disturbing or uprooting trees and vegetation, dumping of soil or debris, or pumping silt-laden water into the stream. Specifications shall require that clean-up, grading, seeding, planting, or restoration of all work areas shall begin immediately. Exposed areas shall not remain unprotected for more than seven (7) days.

(9) Aerial Crossings.

(A) Support shall be provided for all joints in pipes utilized for aerial crossings. The supports shall be designed to prevent frost heave, overturning, and settlement.

(B) Precautions against freezing, such as insulation and increased slope, shall be provided. Expansion jointing shall be provided between above-ground and below-ground sewers. Where buried sewers change to aerial sewers, special construction techniques shall be used to minimize frost heaving.

(C) For aerial stream crossings, the impact of flood waters and debris shall be considered. The bottom of the pipe should be placed no lower than the elevation of the fifty (50)-year flood.

(D) Aerial crossings shall be constructed of ductile-iron pipe with mechanical joints; otherwise, they shall be constructed so that they will remain watertight and free from changes in alignment or grade.

(10) Protection of Water Supplies.

(A) Cross Connections Prohibited. There shall be no physical connections between a public or private potable water supply system and a sewer, or appurtenance thereto which would permit the passage of any wastewater or polluted water into the potable supply. No water pipe shall pass through or come in contact with any part of a sewer manhole.

(B) Relation to Water Works Structures.

1. While no general statement can be made to cover all conditions, it is recognized that sewers shall meet the requirements of 10 CSR 23-3.010 with respect to minimum distances from public water supply wells or other water supply sources and structures.

2. All existing water works units, such as basins, wells, or other treatment units, within two hundred feet (200') (60 m) of the proposed sewer shall be shown on the engineering plans.

(C) Relation to Water Mains.

1. Horizontal and vertical separation.

A. Sewer mains shall be laid at least ten feet (10') (3.0 m) horizontally from any existing or proposed water main. The distances shall be measured edge-to-edge. In cases where it is not practical to maintain a ten-foot (10') (3.0 m) separation, the department may allow deviation on a case-by-case basis, if supported by data from the design engineer. Such a deviation may allow installation of the sewer closer to a water main, provided that the water main is in a separate trench or on an undisturbed earth shelf located on one (1) side of the sewer and at an elevation so the bottom of the water main is at least eighteen inches (18") (46 cm) above the top of the sewer.

B. If it is impossible to obtain proper horizontal and vertical separation as described above for sewers, the sewer must be constructed of slip-on or mechanical joint pipe or continuously encased and be pressure tested to one hundred fifty pounds per square inch (150 psi) (1,034 kPa) to assure watertightness.

C. Manholes should be located at least ten feet (10') (3.0 m) horizontally from any existing or proposed water main.

2. Crossings.

A. Sewers crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") (46 cm) between the outside of the water main and the outside of the sewer. This shall be the case where the water main is either above or below the sewer. The crossing shall be arranged so that the sewer joints will be equidistant and as far as possible from the water main joints. Where a water main crosses under a sewer, adequate structural support shall be provided for the sewer to maintain line and grade.

B. When it is impossible to obtain proper vertical separation as stipulated above, one (1) of the following methods must be specified:

(I) The sewer shall be designed and constructed equal to water pipe and shall be pressure tested to assure watertightness prior to backfilling; or

(II) Either the water main or sewer line may be continuously encased or enclosed in a watertight carrier pipe which extends ten feet (10') (3.0 m) on both sides of the crossing, measured perpendicular to the water main. The carrier pipe shall be of materials approved by the department for use in water main construction.

AUTHORITY: section 644.026, RSMo 2000. Original rule filed Aug. 10, 1978, effective March 11, 1979. Amended: Filed May 17, 1994, effective Dec. 30, 1994. Amended: Filed June 28, 2011, effective Feb. 29, 2012.*

**Original authority 1972, amended 1973, 1987, 1993, 1995.*

10 CSR 20-8.130 Sewage Pumping Stations

PURPOSE: The following criteria have been prepared as a guide for the design of sewage pumping stations. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other

terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day ($85.4m^3$) or less, see 10 CSR 20-8.020 for the requirements for those facilities.

(3) General.

(A) Flooding. Sewage pumping station structures and electrical and mechanical equipment shall be protected from physical damage by the one hundred (100)-year flood. Sewage pumping stations should remain fully operational and accessible during the twenty-five (25)-year flood.

(B) Accessibility. The pumping station shall be readily accessible by maintenance vehicles during all weather conditions. The facility should be located off the traffic way of streets and alleys.

(C) Grit. Where it is necessary to pump sewage prior to grit removal, the design of the wet well and pump station piping shall receive special consideration to avoid operational problems from the accumulation of grit.

(4) Design.

(A) Type. Sewage pumping stations should be of the wet/dry well type. Other types as set forth under sections (5) and (6) of this rule may be approved where circumstances justify their use.

(B) Structures.

1. Separation. Dry wells, including their superstructure, shall be completely separated from the wet well.

2. Equipment removal. Provision shall be made to facilitate removing pumps, motors and other mechanical and electrical equipment.

3. Access. Suitable and safe means of access shall be provided to dry wells and to wet wells containing either bar screens or mechanical equipment requiring inspection or maintenance. For built-in-place pump stations, a stairway with rest landings shall be provided at vertical intervals not to exceed twelve feet (12') (3.7m). For factory-built pump stations over fifteen feet (15') (4.6m) deep, a rigidly fixed landing shall be provided at vertical intervals not to exceed ten feet (10') (3.0m). Where a landing is used, a suitable and rigidly fixed barrier shall be provided to prevent an individual from falling past the intermediate landing to a lower level. Where approved by the agency, a manlift or elevator may be used in lieu of landings in a factory-built station, provided emergency access is included in the design. Reference should be made to local, state and federal safety codes and, if they are more stringent, they shall govern (also see 10 CSR 20-8.140(8)(F)).

4. Construction materials. Due consideration shall be given to the selection of materials because of the presence of hydrogen sulfide and other corrosive gases, greases, oils and other constituents frequently present in sewage.

(C) Pumps and Pneumatic Ejectors.

1. Multiple units. At least two (2) pumps or pneumatic ejectors shall be provided. A minimum of three (3) pumps should be provided for stations handling flows greater than one (1) mgd ($3800m^3/d$). If only two (2) units are provided, they should have the same capacity. Each shall be capable of handling flows in excess of the expected maximum flow. Where three (3) or more units are provided, they should be designed to fit actual flow conditions and must be of a capacity that with any one (1) unit out-of-service the remaining units will have capacity to handle maximum sewage flows.

2. Protection against clogging. Pumps handling combined sewage shall be preceded by readily accessible bar racks to protect the pumps from clogging or damage. Bar racks should have clear openings not exceeding two and one-half inches (2 1/2") (6.4 cm). Where a bar rack is provided, a mechanical hoist shall also be provided. Where the size of the installation warrants, mechanically cleaned and/or duplicate bar racks shall be provided. Pumps handling separate sanitary sewage from thirty inches (30") (76 cm) or larger diameter sewers shall be protected by bar racks meeting these requirements. Appropriate protection from clogging shall also be considered for small pumping stations.

3. Pump openings. Except where grinder pumps are used, pumps shall be capable of passing spheres of at least three inches (3") (7.6 cm) in diameter and pump suction and discharge piping shall be at least four inches (4") (10.2 cm) in diameter.

4. Priming. The pump shall be so placed that under normal operating conditions it will operate under a positive suction head, except as specified in section (5) of this rule.

5. Electrical equipment. Electrical systems and components (for example, motors, lights, cables, conduits, switchboxes, control circuits, etc.) in enclosed or partially enclosed spaces where hazardous concentrations of flammable gases or vapors may be present, including raw sewage wet wells, shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location). In addition, equipment located in the wet well shall be suitable for use under corrosive conditions. Each flexible cable shall be provided with watertight seal and separate strain relief. A fused disconnect switch located above ground shall be provided for all pumping stations. When the equipment is exposed to weather, it shall meet the requirements of weather proof equipment (NEMA 3R).

6. Intake. Each pump should have an additional individual intake. Wet well design should be such as to avoid turbulence near the intake. Intake piping should be as straight and short as possible.

7. Dry well de-watering. A separate sump pump equipped with dual check valves shall be provided in the dry wells to remove leakage or drainage with the discharge located as high as possible. A connection to the pump suction is also recommended as an auxiliary feature. Water ejectors connected to a potable water supply will not be approved. All floor and walkway surfaces should have an adequate slope to a point of drainage. Pump seal water shall be piped to the sump.

8. Pumping rates. The pumps and controls of main pumping stations and especially pumping stations pumping to the treatment works or operated as part of the treatment works should be selected to operate at varying delivery rates to permit discharging sewage at approximately its rate of delivery to the pump station. Design pumping rates should be established in accordance with 10 CSR 20-8.120(5) or 10 CSR 20-8.140(5)(C)1. as appropriate.

(D) Controls.

1. Type. Control systems shall be of the air bubbler type, the encapsulated float type or the flow measuring type. Float tube control systems on existing stations being upgraded may be approved. The electrical equipment shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

2. Location. The control system shall be located away from the turbulence of incoming flow and pump suction.

3. Alternation. In small stations, provisions should be made to automatically alternate the pumps in use.

(E) Valves.

1. Suitable shutoff valves shall be placed on the suction line of each pump except on submersible and vacuum primed pumps.

2. Suitable shutoff and check valves shall be placed on the discharge line of each pump. The check valve shall be located between the shutoff valve and the pump. Check valves shall be suitable for the material being handled. Check valves shall not be placed on the vertical portion of discharge

Schedule JAM-5

piping. Valves shall be capable of withstanding normal pressure and water hammer. Where limited pump backspin will not damage the pump and low discharge head conditions exist, short individual force mains for each pump may be considered in lieu of discharge valves.

3. Valves shall not be located in the wet well.

(F) Wet Wells.

1. Divided wells. Consideration should be given to dividing the wet well into multiple sections, properly interconnected, to facilitate repairs and cleaning.

2. Size. The wet well size and control setting shall be appropriate to avoid heat buildup in the pump motor due to frequent starting and to avoid septic conditions due to excessive detention time.

3. Floor slope. The wet well floor shall have a minimum slope of one to one (1:1) to the hopper bottom. The horizontal area of the hopper bottom shall not be greater than necessary for proper installation and function of the inlet.

(G) Ventilation. Adequate ventilation shall be provided for all pump stations. Where the pump pit is below the ground surface, mechanical ventilation is required, so arranged as to independently ventilate the dry well and the wet well if screens or mechanical equipment requiring maintenance or inspection are located in the wet well. There shall be no interconnection between the wet well and dry well ventilation systems. In pits over fifteen feet (15') (4.6m) deep, multiple inlets and outlets are desirable. Dampers should not be used on exhaust or fresh air ducts and fine screens or other obstructions in air ducts should be avoided to prevent clogging. Switches for operation of ventilation equipment should be marked and located conveniently. All intermittently operated ventilating equipment shall be interconnected with the respective pit lighting system. Consideration should be given also to automatic controls where intermittent operation is used. The fan wheel should be fabricated from non-sparking material. Consideration should be given to installation of automatic heating and/or dehumidification equipment.

1. Wet wells. Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least twelve (12) complete air changes per hour, if intermittent, at least thirty (30) complete air changes per hour. Air shall be forced into the wet well rather than exhausted from the wet well.

2. Dry wells. Ventilation may be either continuous or intermittent. Ventilation, if continuous, shall provide at least six (6) complete air changes per hour, if intermittent, at least thirty (30) complete air changes per hour.

(H) Flow Measurement. Suitable devices for measuring sewage flow should be considered at all pumping stations.

(I) Water Supply. There shall be no physical connection between any potable water supply and a sewage pumping station which under any conditions might cause contamination of the potable water supply. If a potable water supply is brought to the station, it should comply with conditions stipulated under 10 CSR 20-8.140(8)(B).

(5) Suction Lift Pumps. Suction lift pumps shall be of the self priming or vacuum priming type and shall meet the applicable requirements under section (4) of this rule. Suction lift pump stations using dynamic suction lifts exceeding the limits outlined in the following subsections may be approved by the agency upon submission of factory certification of pump performance and detail calculations indicating satisfactory performance under the proposed operating conditions. Detail calculations must include static suction lift as measured from “lead pump off” elevation to center line of pump suction, friction and other hydraulic losses of the suction piping, vapor pressure of the liquid, altitude correction, required net positive suction head and a safety factor of at least six feet (6') (1.8m). The pump equipment compartment shall be above grade or offset and shall be effectively isolated from the wet well to prevent the humid and corrosive sewer atmosphere from entering the equipment compartment. Wet well access shall not be through the equipment compartment. Valving shall not be located in the wet well.

(A) Self-Priming Pumps. Self-priming pumps shall be capable of rapid priming and repriming at the “lead pump on” elevation. This self-priming and repriming shall be accomplished automatically under design operating conditions. Suction piping should not exceed the size of the pump suction and shall not exceed twenty-five feet (25') (7.6m) in total length. Priming lift at the ‘’lead pump on’’ elevation shall include a safety factor of at least four feet (4') (1.2m) from the maximum allowable priming lift for the specific equipment at design operating conditions. The combined total of dynamic suction lift at the “pump off” elevation and required net positive suction head at design operating conditions shall not exceed twenty-two feet (22') (6.7m).

(B) Vacuum Priming Pumps. Vacuum priming pump stations shall be equipped with dual vacuum pumps capable of automatically and completely removing air from the suction lift pump. The vacuum pumps shall be adequately protected from damage due to sewage. The combined total of dynamic suction lift at the “pump off” elevation and required net positive suction head at design operating conditions shall not exceed twenty-two feet (22") (6.7m).

(6) Submersible Pump Stations. Submersible pump stations shall meet the applicable requirements under section (4) of this rule, except as modified in this section.

(A) Construction. Submersible pumps and motors shall be designed specifically for raw sewage use, including totally submerged operation during a portion of each pumping cycle. An effective method to detect shaft seal failure or potential seal failure shall be provided and the motor shall be of squirrel-cage type design without brushes or other arc-producing mechanisms.

(B) Pump Removal. Submersible pumps shall be readily removable and replaceable without de-watering the wet well or disconnecting any piping in the wet well.

(C) Electrical.

1. Power supply and control. Electrical supply and control circuits shall be designed to allow disconnection at a junction box located or accessible from outside the wet well. Terminals and connectors shall be protected from corrosion by location outside of the wet well or by watertight seals.

2. Controls. The motor control center shall be located outside the wet well and be protected by a conduit seal to prevent the atmosphere in the wet well from gaining access to the control center. The seal shall be located so that the motor may be removed and electrically disconnected without disturbing the seal.

3. Power cord. Pump motor power cords shall be designed for flexibility and serviceability under conditions of extra hard usage and shall meet the requirements of the Mine Safety and Health Administration for trailing cables. Ground fault interruption protection shall be used to de-energize the circuit in the event of any failure in the electrical integrity of the cable. Power cord terminal fittings shall be corrosion resistant and be constructed in a manner to prevent the entry of moisture into the cable, shall be provided with strain relief appurtenances and shall be designed to facilitate field connecting.

(D) Valves. Valves required under subsection (4)(E) of this rule shall be located in a separate valve pit. Accumulated water shall be drained to the wet well or to the soil. If the valve pit is drained to the wet well, an effective method shall be provided to prevent sewage from entering the pit during surcharged wet well conditions.

(7) Alarm Systems. Alarm systems shall be provided for pumping stations. The alarm shall be activated in cases of power failure, pump failure, use of the lag pump, unauthorized entry or any cause of pump station malfunction. Pumping station alarms shall be telemetered, including identification of the alarm condition, to a municipal facility that is manned twenty-four (24) hours a day. If such a facility is not available and twenty-four (24)-hour holding capacity is not provided, the alarm shall be telemetered to city offices during normal working hours and to the home of the person(s) responsible in charge of the lift station during off-duty hours. Audiovisual alarm systems with a self-contained power supply may be acceptable in some cases in lieu of the telemetering system outlined in this section, depending upon location, station holding capacity and inspection frequency.

(8) Emergency Operation. Pumping stations and collection systems shall be designed to prevent or minimize bypassing of raw sewage. For use during possible periods of extensive power outages, mandatory power reductions or uncontrolled storm events, consideration should be given to providing a controlled, high-level wet well overflow to supplement alarm systems and emergency power generation in order to prevent backup of sewage into basements, or other discharges which may cause severe adverse impacts on public interests, including public health and property damage. Where a controlled diversion is utilized, consideration shall also be given to the installation of storage-detention tanks or basins, which will be made to drain to the station wet well. Where overflows affect public water supplies, shellfish production or waters used for culinary or food processing purposes, a storage-detention basin or tank, shall be provided having two (2)-hour detention capacity at the anticipated overflow rate.

(A) Overflow Prevention Methods. A satisfactory method shall be provided to prevent or minimize overflows. The following methods should be evaluated on an individual basis. The choice should be based on least cost and least operational problems of the methods providing an acceptable degree of reliability. The methods are—

1. Storage capacity including trunk sewers for retention of wet weather flows. Storage basins must be designed to drain back into the wet well or collection system after the flow recedes;

2. An in-place or portable pump, driven by an internal combustion engine meeting the requirements of subsection (8)(B) of this rule, capable of pumping from the wet well to the discharge side of the station; and

3. Two (2) independent public utility sources or engine-driven generating equipment meeting the requirements of subsection (8)(B) of this rule.

(B) Equipment Requirements.

1. General. The following general requirements shall apply to all internal combustion engines used to drive auxiliary pumps, service pumps through special drives or electrical generating equipment.

A. Engine protection. The engine must be protected from operating conditions that would result in damage to equipment. Unless continuous manual supervision is planned, protective equipment shall be capable of shutting down the engine and activating an alarm on-site and as provided in section (7) of this rule. Protective equipment shall monitor for conditions of low oil pressure and overheating, except oil pressure monitoring will not be required for engines with splash lubrication.

B. Size. The engine shall have adequate rated power to start and continuously operate all connected loads.

C. Fuel type. Reliability and ease of starting, especially during cold weather conditions should be considered in the selection of the type of fuel.

D. Engine ventilation. The engine shall be located above grade with adequate ventilation of fuel vapors and exhaust gases.

E. Routine start-up. All emergency equipment shall be provided with instructions indicating the need for regular starting and running of the units at full loads.

F. Protection of equipment. Emergency equipment shall be protected from damage at the restoration of regular electrical power.

2. Engine-driven pumping equipment. Where permanently installed or portable engine-driven pumps are used, the following requirements in addition to general requirements shall apply:

A. Pumping capacity. Engine-driven pump(s) shall meet the design pumping requirements unless storage capacity is available for flows in excess of pump capacity. Pumps shall be designed for anticipated operating conditions, including suction lift if applicable;

B. Operation. The engine and pump shall be equipped to provide automatic start-up and operation of pumping equipment. Provisions shall also be made for manual start-up. Where manual start-up and operation is justified, storage capacity and alarm system must meet the requirements of subparagraph (8)(B)2.C. of this rule; and

C. Portable pumping systems. Where part or all of the engine-driven pumping equipment is portable, sufficient storage capacity to allow time for detection of pump station failure and transportation and hookup of the portable equipment shall be provided. A riser from the force main with quick-connect coupling and appropriate valving shall be provided to hookup portable pumps.

3. Engine-driven generating equipment. Where permanently installed or portable engine-driven generating equipment is used, the following requirements in addition to general requirements shall apply:

A. Generating capacity. Generating unit size shall be adequate to provide power for pump motor starting current and for lighting, ventilation and other auxiliary equipment necessary for safety and proper operation of the lift station. The operation of only one (1) pump during periods of auxiliary power supply must be justified. Justification may be made on the basis of maximum anticipated flows relative to single pump capacity, anticipated length of power outage and storage capacity. Special sequencing controls shall be provided to start pump motors unless the generating equipment has capacity to start all pumps simultaneously with auxiliary equipment operating;

B. Operation. Provisions shall be made for automatic and manual start-up and load transfer. The generator must be protected from operating conditions that would result in damage to equipment. Provisions should be considered to allow the engine to start and stabilize at operating speed before assuming the load. Where manual start-up and transfer is justified, storage capacity and alarm system must meet the requirements of subparagraph (8)(B)3.C. of this rule; and

C. Portable generating equipment. Where portable generating equipment or manual transfer is provided, sufficient storage capacity to allow time for detection of pump station failure and transportation and connection of generating equipment shall be provided. The use of special electrical connections and double throw switches are recommended for connecting portable generating equipment.

(9) Grinder Pumps in Pressure Sewer Systems. A pressure sewer system is defined as two (2) or more grinder pump units at different locations discharging into a common force main. Grinder pump units and pressure systems are not to be used in lieu of conventional gravity collection systems; however, grinder pumps may be used where it is not

Schedule JAM-5

feasible to provide conventional gravity sewer service, such as where the topography makes it difficult for the users to be served by a conventional system, groundwater conditions make construction and maintenance of a conventional system difficult or excessive rock excavation makes a conventional system impractical. The operating authority shall be responsible for the entire system which shall include the force mains, grinder pump units and appurtenances.

(A) Pump Openings. The grinder unit must be capable of reducing any material which enters the grinder unit to a size that the materials will pass through the pump unit and force main without plugging or clogging. No screens or other devices requiring regular maintenance may be used to keep trashy or stringy material out of the grinder pump or force main. This requirement shall be in lieu of the requirements in paragraph (4)(C)3. of this rule.

(B) Storage Capacity. The minimum storage capacity of the grinder pump unit shall be fifty (50) gallons (189 l). The unit shall be capable of accommodating normal peak flows for periods of eight to twelve (8–12) hours.

(C) Alarm System. For grinder pump units serving a single home, an audiovisual alarm capable of alerting the resident and operating personnel in the area may be used in lieu of the alarm system specified in section (7) of this rule.

(D) Valves. A gate valve must be provided on the service line near the common force main.

(E) Force Main Velocity. The velocity shall meet the requirements of subsection (11)(A) of this rule based on the most probable number of pump units expected to operate simultaneously or on some other acceptable method of computing the peak pumpage rate.

(F) Cleaning. Consideration should be given to providing a suitable method of cleaning the force main whenever the velocity in the force main may be less than two feet (2') per second (0.61m/s) before ultimate development is reached.

(G) Electrical. Units must be serviceable and replaceable under wet conditions without electrical hazard to repair personnel. Electrical equipment shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

(H) Standby Units. One (1) standby unit for each fifty (50) units or fraction thereof must be provided for each model installed.

(I) Service Interruptions. Provisions shall be made to avoid interruption of service due to mechanical or power failure by providing standby power, storage capacity or interconnection with another disposal system.

(10) Instructions and Equipment. Sewage pumping stations and their operators should be supplied with a complete set of operational instructions, including emergency procedures, maintenance schedules, special tools and spare parts as may be necessary.

(11) Force Mains.

(A) Velocity. At design average flow a velocity of at least two feet (2') per second (0.61m/s) shall be maintained.

(B) Air Relief Valve. An air relief valve shall be placed at high points in the force main to prevent air locking. When accumulation of air or decomposition gases are likely, an automatic air relief valve suitable for use on sewage force mains shall be used.

(C) Termination. Force mains should enter the gravity sewer system at a point not more than two feet (2') (30 cm) above the flow line of the receiving manhole.

(D) Design Pressure. The force main and fittings including reaction blocking shall be designed to withstand normal pressure and pressure surges (water hammer).

(E) Special Construction. Force main construction near streams or used for aerial crossings shall meet applicable requirements of 10 CSR 20-8.120(9) and (10).

(F) Design Friction Losses. Friction losses through force mains shall be based on the Hazen and Williams formula or other acceptable method. When the Hazen and Williams formula is used, the following values for “C” shall be used for design; unlined iron or steel—one hundred (100) and all other—one hundred twenty (120). When initially installed, force mains will have a significantly higher “C” factor. The higher “C” factor should be considered only in calculating maximum power requirements.

(G) Separation from Water Mains. There shall be at least a ten-foot (10') (3.0 m) horizontal separation between water mains and sanitary sewer force mains. Force mains crossing water mains shall be laid to provide a minimum vertical distance of eighteen inches (18") (46 cm) between the outside of the force main and the outside of the water main. This shall be the case where the water main is either above or below the force main. At crossings, one (1) full length of water pipe shall be located so both joints will be as far from the force main as possible. Special structural support for the water main and force main may be required.

(H) Identification of Force Mains. Where force mains are constructed of material which might cause the force main to be confused with potable water mains, the force main should be appropriately identified.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.140 Sewage Treatment Works

PURPOSE: The following criteria have been prepared as a guide for the general design requirements for sewage treatment works. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor’s Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Plant Location. The following items shall be considered when selecting a plant site: proximity to residential areas; direction of prevailing winds; accessibility by all-weather roads; area available for expansion; local zoning requirements; local soil characteristics, geology, hydrology and topography available to minimize pumping; access to receiving stream; downstream uses of the receiving stream and compatibility of treatment process with the present and planned future land use, including noise, potential odors, air quality and anticipated sludge processing and disposal techniques. Where a site must be used which is critical with respect to these items, appropriate measures shall be taken to minimize adverse impacts.

(A) Flood Protection. The treatment works structures, electrical and mechanical equipment shall be protected from physical damage by the one hundred (100)-year flood. Treatment works should remain fully operational and accessible during the twenty-five (25)-year flood. This applies to new construction and to existing facilities undergoing major modification.

(4) Quality of Effluent. The required degree of wastewater treatment shall be based on 10 CSR 20-7.015, Effluent Regulations and 10 CSR 20-7.031, Water Quality Standards.

(5) Design.

(A) Type of Treatment. As a minimum, the following items shall be considered in the selection of the type of treatment: present and future effluent requirements; location of and local topography of the plant site; space available for future plant construction; the effects of industrial wastes likely to be encountered; ultimate disposal of sludge; system capital costs; system operating and maintenance costs, including basic energy requirements; process complexity governing operating personnel requirements; and environmental impact on present and future adjacent land use.

(B) Required Engineering Data for New Process Evaluation. The policy of the agency is to encourage rather than obstruct the development of any methods or equipment for treatment of wastewater. The lack of inclusion in these standards of some types of wastewater treatment processes or equipment should not be construed as precluding their use. The agency may approve other types of wastewater treatment processes and equipment under the following conditions: the operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably sized prototype unit operating at its design load conditions to the extent required by the agency; the agency may require monitoring observations, including test results and engineering evaluations, demonstrating the efficiency of the processes, detailed description of the test methods; testing, including appropriately composited samples, under various ranges of strength and flow rates (including diurnal) and waste temperature over a sufficient length of time to demonstrate performance under climatic and other conditions which may be encountered in the area of the proposed installations and other appropriate information; the agency may require that appropriate testing be conducted and evaluations be made under the supervision of a competent process engineer other than those employed by the manufacturer or developer.

(C) Design Loads.

1. Hydraulic design.

A. New systems.

(I) Undeveloped areas. The design for sewage treatment plants to serve new sewerage systems being built in currently undeveloped areas shall be based on an average daily flow of one hundred (100) gallons per capita (378 l/cap), unless water use data or other justification upon which to better estimate flow is provided.

(II) Existing developed areas. Consideration shall be given in the designs for sewage treatment plants to serve a new sewerage system for a municipality or sewer district for higher flow rates if a large percentage of older buildings are likely to contribute significant infiltration/inflow to the new sanitary sewer system through basement floor drains.

B. Existing systems. Where there is an existing system, the volume and strength of existing flows shall be determined. The determination shall include both dry weather and wet weather conditions. Samples shall be taken and composited so as to be accurately representative of the strength of the wastewater. At least one (1) year's flow data should be taken as the basis for the preparation of hydrographs for analysis to determine the following types of flow conditions of the system: the annual average daily flow—as determined by averaging flows over one (1) year, exclusive of inflow due to rainfall; the minimum daily flow—as determined by observing twenty-four (24)-hour flows during dry weather (low rainfall period) when infiltration/inflow are at a minimum; wet weather peak flows—as determined by observing twenty-four (24)-hour flows during a period of one (1) year when infiltration/inflow are at a maximum; wet weather flows of seven (7)-day duration—as determined by observing for a period of one (1) year the daily flows during the immediate seven (7)-day period following rainfall sufficient to cause ground surface runoff; peak hourly flows—as determined by observing the maximum hydraulic load to the plant; and industrial waste flows—as determined by flow data, including water use records, for each of the industries tributary to the sewer system. The plant design flow selected shall meet the appropriate effluent and water quality standards in 10 CSR 20-7.015 and 10 CSR 20-7.031.

C. Flow equalization. Facilities for the equalization of flows and organic shock load shall be considered at all plants which are critically affected by surge loadings. The sizing of the flow equalization facilities should be based on data obtained from paragraph (5)(C)1. of this rule and 10 CSR 20-8.120(5)(B).

2. Organic design.

A. New system minimum design. Domestic waste treatment design shall be on the basis of at least 0.17 pounds (0.08 kg) of biochemical oxygen demand (BOD) per capita per day and 0.20 pounds (0.09 kg) of suspended solids per capita per day, unless information is submitted to justify alternate designs; when garbage grinders are used in areas tributary to a domestic treatment plant, the design basis should be increased to 0.22 pounds (0.10 kg) of BOD per capita per day and 0.25 pounds (0.11 kg) of suspended solids per capita per day; domestic waste treatment plants that will receive industrial wastewater flows shall be designed to include these industrial waste loads.

B. Existing systems. When an existing treatment works is to be upgraded or expanded, the organic design shall be based upon the actual strength of the wastewater as determined from the measurements taken in accordance with subparagraph (5)(C)1.B. of this rule, with an appropriate increment for growth.

3. Shock effects. The shock effects of high concentrations and diurnal peaks for short periods of time on the treatment process, particularly for small treatment plants, shall be considered.

4. Design by analogy. Data from similar municipalities may be utilized in the case of new systems; however, thorough investigation that is adequately documented shall be provided to the agency to establish the reliability and applicability of the data.

(D) Conduits. All piping and channels should be designed to carry the maximum

Schedule JAM-5

expected flows. The incoming sewer should be designed for unrestricted flow. Bottom corners of the channels must be filleted. Conduits shall be designed to avoid creation of pockets and corners where solids can accumulate. Suitable gates should be placed in the channels to seal off unused sections which might accumulate solids. The use of shear gates or stop planks is permitted where they can be used in place of gate valves or sluice gates. Noncorrosive materials shall be used for these control gates.

(E) Arrangement of Units. Component parts of the plant should be arranged for greatest operating and maintenance convenience, flexibility, economy, continuity of maximum effluent quality so as to facilitate installation of future units.

(F) Flow Division Control. Flow division control facilities shall be provided as necessary to insure organic and hydraulic loading control to plant process units and shall be designed for easy operator access, change, observation and maintenance. Appropriate flow measurement shall be incorporated in the flow division control design.

(6) Plant Details.

(A) Installation of Mechanical Equipment. The specifications should be so written that the installation and initial operation of major items of mechanical equipment will be supervised by a representative of the manufacturer.

(B) Unit Isolation. Properly located and arranged structures and piping shall be provided so that each unit of the plant can be removed from service independently. The design shall facilitate plant operation during unit maintenance and emergency repair so as to minimize deterioration of effluent quality and insure rapid process recovery upon return to normal operational mode.

1. Continuity during construction. Final plan documents shall include construction requirements as deemed necessary by the agency to avoid unacceptable temporary water quality degradation.

(C) Drains. Means shall be provided to dewater each unit to an appropriate point in the process. Due consideration shall be given to the possible need for hydrostatic pressure relief devices to prevent flotation of structures. Pipes subject to clogging shall be provided with means for mechanical cleaning or flushing.

(D) Construction Materials. Due consideration should be given to the selection of materials which are to be used in sewage treatment works because of the possible presence of hydrogen sulfide and other corrosive gases, greases, oils or similar constituents frequently present in sewage. This is particularly important in the selection of metals and paints. Contact between dissimilar metals should be avoided to minimize galvanic action.

(E) Painting. The use of paints containing lead or mercury should be avoided. In order to facilitate identification of piping, particularly in the large plants, it is suggested that different lines be color coded. The following color scheme is recommended for purposes of standardization: sludge line—brown; gas line—orange; potable water line—blue; chlorine line—yellow; sewage line—gray; compressed air line—green; and water lines for heating digesters or buildings—blue with a six inch (6") (15 cm) red band spaced thirty inches (30") (76 cm) apart. The contents shall be stenciled on the piping in contrasting color.

(F) Operating Equipment. A complete outfit of tools, accessories and spare parts necessary for the plant operator's use shall be provided. Readily accessible storage space and workbench facilities shall be provided and consideration be given to provision of a garage storage area for large equipment, maintenance and repair.

(G) Erosion Control During Construction. Effective site erosion control shall be provided during construction.

(H) Grading and Landscaping. Upon completion of the plant, the ground should be graded. Concrete or gravel walkways should be provided for access to all units. Where possible, steep slopes should be avoided to prevent erosion. Surface water shall not be permitted to drain into any unit. Particular care shall be taken to protect trickling filter beds, sludge beds and intermittent sand filters from stormwater runoff. Provision should be made for landscaping, particularly when a plant must be located near residential areas.

(7) Plant Outfalls.

(A) Entrance Impact Control. The outfall sewer shall be designed to discharge to the receiving stream in a manner acceptable to the agency. Consideration should be given in each case to the following: preference for free fall or submerged discharge at the site selected; utilization of cascade aeration of effluent discharge to increase dissolved oxygen; limited or complete across stream dispersion as needed to protect aquatic life movement and growth in the immediate reaches of the receiving stream; appropriate effluent sampling in accordance with subsection (7)(C) of this rule.

(B) Protection and Maintenance. The outfall sewer shall be so constructed and protected against the effects of flood water, ice or other hazards as to reasonably insure its structural stability and freedom from stoppage. A manhole should be provided at the shore end of all gravity sewers extending into the receiving waters. Hazards to navigation shall be considered in designing outfall sewers.

(C) Sampling Provisions. All outfalls shall be designed so that a sample of the effluent can be obtained at a point after the final treatment process and before discharge to or mixing with the receiving waters.

(8) Essential Facilities.

(A) Emergency Power Facilities. All plants shall be provided with an alternate source of electric power to allow continuity of operation during power failures, except as noted in this subsection. Methods of providing alternates include the connection of at least two (2) independent public utility sources, such as substations; a power line from each substation is recommended and will be required unless, documentation is received and approved by the agency verifying that duplicate line is not necessary to minimize water quality violations; portable or inplace internal combustion engine equipment which will generate electrical or mechanical energy; and portable pumping equipment when only emergency pumping is required.

1. Standby generating capacity normally is not required for aeration equipment used in the activated sludge process. In cases where a history of long-term (four (4) hours or more) power outages have occurred, auxiliary power for minimum aeration of the activated sludge will be required. Full power generating capacity may be required by the agency on certain stream segments.

2. Continuous disinfection, where required, shall be provided during all power outages.

(B) Water Supply.

1. General. An adequate supply of potable water under pressure should be provided for use in the laboratory and for general cleanliness around the plant. No piping or other connections shall exist in any part of the treatment works which, under any conditions, might cause the contamination of a potable water supply. The chemical quality should be checked for suitability for its intended uses, such as heat exchangers, chlorinators, etc.

2. Direct connections. Potable water from a municipal or separate supply may be used directly at points above grade for the following hot and cold supplies: lavatory; water closet; laboratory sink (with vacuum breaker); shower; drinking fountain; eye wash fountain; and safety shower. Hot water for any of these units shall not be taken directly from a boiler used for supplying hot water to

Schedule JAM-5

a sludge heat exchanger or digester heating coils.

3. Indirect connections. A reduced pressure backflow preventer or a break tank shall be used to isolate the potable system from all other plant uses other than those listed in paragraph (8)(B)2. of this rule. Where permanent connections are to be made to uses other than those listed in paragraph (8)(B)2. of this rule, a break tank shall be used. Where a break tank is used, water shall be discharged to the break tank through an air-gap at least six inches (6") above the maximum flood line, ground level or the spill line of the tank, whichever is higher. Backflow preventers shall be located above the maximum flood line or ground level. A sign shall be permanently posted at every hose bib, faucet, hydrant or sill cock located on the water system beyond the break tank or backflow preventer to indicate that the water is not safe for drinking.

4. Separate potable water supply. Where it is not possible to provide potable water from a public water supply, a separate well may be provided. Location and construction of the well should comply with requirements of 10 CSR 60-2.010. Requirements governing the use of the supply are those contained in paragraphs (8)(B)2. and 3. of this rule.

5. Separate nonpotable water supply. Where a separate nonpotable water supply is to be provided, a break tank will not be necessary, but all system outlets shall be posted with a permanent sign indicating the water is not safe for drinking.

(C) Sanitary Facilities. Toilet, shower, lavatory and locker facilities should be provided in sufficient numbers and convenient locations to serve the expected plant personnel.

(D) Laboratory. All treatment works shall include a laboratory for making the necessary analytical determinations and operating control tests, except in individual situations where other arrangements are approved by the agency. The laboratory shall have sufficient size, bench space, equipment and supplies to perform all self-monitoring analytical work required by discharge permits and to perform the process control tests necessary for good management of each treatment process included in the design. The facilities and supplies necessary to perform analytical work to support industrial waste control programs will normally be included in the same laboratory. The laboratory size and arrangement must be sufficiently flexible and adaptable to accomplish these assignments. The layout should consider future needs for expansion in the event that more analytical work is needed.

1. Location and space. The laboratory should be located on ground level, easily accessible to all sampling points, with environmental control as an important consideration. It shall be located away from vibrating machinery or equipment which might have adverse effects on the performance of laboratory instruments or the analyst or design or to prevent adverse effects from vibration. A minimum of four hundred (400) square feet (37m^3) of floor space should be allocated for the laboratory. If more than two (2) persons will be working in the laboratory at any given time, one hundred (100) square feet (9.3m^3) of additional space should be provided for each additional person. Bench top working surface should occupy at least thirty-five percent (35%) of the total floor space. Minimum ceiling height should be eight feet six inches (8'6") (2 m). If possible this height should be increased to provide for installation of wall-mounted water stills, distillation racks and other equipment with extended height requirements.

2. Materials.

A. Ceilings. Acoustical tile should be used for ceiling except in high humidity areas where they should be constructed of plaster.

B. Walls. For easy maintenance and a pleasant working environment, light colored ceramic tile should be used from floor to ceiling for all interior walls.

C. Floors. Floor surfaces should be either vinyl asbestos or rubber, fire-resistant and highly resistant to acids, alkalies, solvents and salts.

D. Doors. Two (2) exit doors should be located to permit a straight egress from the laboratory preferably at least one (1) to outside the building. Panic hardware should be used. They should have large glass windows for easy visibility of approaching or departing personnel. Automatic door closers should be installed; swinging doors should not be used. Flush hardware should be provided doors if cart traffic is anticipated. Kick plates are also recommended.

3. Cabinets and bench tops. Wall hung cabinets are useful for dust-free storage of instruments and glassware. Units with sliding doors are preferable. They should be hung so the top shelf is easily accessible to the analyst. Thirty inches (30") (76 cm) from the bench top is recommended. One (1) or more cupboard style base cabinets should be provided for storing large items; however, drawer units are preferred for the remaining cabinets. Drawers should slide out so that entire contents are easily visible. They should be provided with rubber bumpers and with stops which prevent accidental removal. Drawers should be supported on ball bearings or nylon rollers which pull easily in adjustable steel channels. All metal drawer fronts should be of double wall construction. All cabinet shelving should be acid resistant and adjustable from inside the cabinet. Water, gas, air and vacuum service fixtures; traps, strainers, overflows, plugs and tailpieces; and all electrical service fixtures shall be supplied with the laboratory furniture. Generally, bench top height should be thirty-six inches (36") (91 cm). However, areas to be used exclusively for sit-down type operations should be thirty inches (30") (76 cm) high and include knee hole space. One-inch (1") (2.54 cm) overhangs and drip grooves should be provided to keep liquid spills from running along the face of the cabinet. Tops should be furnished in large sections one and one-fourth inches (1 1/4") (3.18 cm) thick. They should be field joined into a continuous surface with acid, alkali and solvent resistant cements which are at least as strong as the material of which the top is made.

4. Hoods. Fume hoods to promote safety and canopy hoods over heat releasing equipment shall be installed.

A. Fume hoods.

(I) Location. Fume hoods should be located where air disturbance at the face of the hood is minimal. Air disturbance may be created by persons walking past the hood, supply in diffusers, drafts from opening or closing a door, etc. Safety factors should be considered in locating a hood. If a hood is situated near a doorway, a secondary means of egress must be provided. Bench surfaces should be available next to the hood so that chemicals need not be carried long distances.

(II) Design and materials. The selection of fume hoods, their design and materials of construction must be made considering the variety of analytical work to be performed and the characteristics of the fumes, chemicals, gases or vapors that will or may be released by the activities therein. Special design and construction is necessary if perchloric acid use is anticipated. Consideration should be given for providing more than one (1) fume hood to minimize potential hazardous conditions throughout the laboratory. Fume hoods are not appropriate for operation of heat releasing equipment, that does not contribute to hazards, unless they are provided in addition to those needed to perform hazardous tasks.

(III) Fixtures. A cup sink should be provided inside each fume hood. All switches, electrical outlets, utility and baffle adjustment handles should be located outside the hood. Light fixtures should be explosion proof.

Schedule JAM-5

(IV) Exhaust. Twenty-four (24)-hour continuous exhaust capability should be provided. Exhaust fans should be explosion proof. Exhaust velocities should be checked when fume hoods are installed.

(V) Alarms. A buzzer for indicating exhaust fan failure and a static pressure gauge should be placed in the exhaust duct. A high temperature sensing device located inside the hood should be connected to the buzzer.

(VI) Canopy hoods. Canopy hoods should be installed over the bench top areas where hot plate, steam bath or other heating equipment or heat releasing instruments are used. The canopies should be constructed of steel, plastic or equivalent material and finished with enamel to blend with other laboratory furnishings.

5. Sinks. The laboratory shall be equipped with at least one (1) double-wall sink with drainboards. Additional sinks should be provided in separate work areas as needed and identified for the use intended. Sinks should be made of epoxy resin or plastic material with all appropriate characteristics for laboratory applications. Waste openings should be located toward the back so that a standing overflow will not interfere. All water fixtures on which hoses may be used should be provided with reduced zone pressure backflow preventers to prevent contamination of water lines. The sinks should be constructed of material highly resistant to acids, alkalies, solvents and salts, should be abrasion and heat resistant, nonabsorbent and light in weight. Traps should be made of glass, plastic or lead and easily accessible for cleaning.

6. Ventilation and lighting. Laboratories should be separately air conditioned with external air supply for one hundred percent (100%) makeup volume. In addition, separate exhaust ventilation should be provided. Ventilation outlet locations should be remote from ventilation inlets. Good lighting, free from shadows, is important for reading dials, meniscuses, etc., in the laboratory.

7. Gas and vacuum. Natural gas should be supplied to the laboratory. Digester gas should not be used. An adequately sized line source of vacuum should be provided with outlets available throughout the laboratory.

8. Balance and table. An analytical balance of the automatic, digital readout, single pan 0.1 milligram sensitivity type shall be provided. A heavy special design balance table which will minimize vibration of the balance shall be provided. It shall be located as remote as possible from windows, doors or other sources of drafts or air movements, so as to minimize undesirable impacts from these sources upon the balance.

9. Equipment, supplies and reagents. The laboratory shall be provided with all of the equipment, supplies and reagents that are needed to carry out all of the facility's analytical testing requirements. Discharge permit requirements, process control requirements and industrial waste monitoring requirements should be considered when specifying equipment needs.

(E) Floor Slope. Floor surfaces shall be sloped adequately to a point of drainage.

(F) Stairways. Stairways shall be installed wherever possible in lieu of ladders. Spiral or winding stairs are permitted only for secondary access where dual means of egress are provided. Stairways shall have slopes between fifty degrees (50°) and thirty degrees (30°) (preferably nearer the latter) from the horizontal to facilitate carrying samples, tools, etc. Each tread and riser shall be of uniform dimension in each flight. Minimum tread run shall not be less than eight inches (8") (20.3 cm). The sum of the tread run and riser shall not be less than seventeen inches (17") (43 cm) nor more than eighteen inches (18") (46 cm). A flight of stairs shall consist of not more than a twelve-foot (12') (3.7 m) continuous rise without a platform.

(G) Flow Measurement. Flow measurement facilities shall be provided at all plants. Indicating, totalizing and recording flow measurement devices shall be provided for all mechanical plants. Flow measurement facilities for lagoon systems shall not be less than pump calibration time clocks or calibrated flume and shall be provided on both the influent and effluent.

(9) Safety. Adequate provision shall be made to effectively protect the operator and visitors from hazards, the following shall be provided to fulfill the particular needs of each plant: enclosure of the plant site with a fence designed to discourage the entrance of unauthorized persons and animals; installation of hand rails and guards around tanks, trenches, pits, stairwells and other hazardous structures; provision of first-aid equipment; posting of "No Smoking" signs in hazardous areas; provision of protective clothing and equipment such as air pacs, goggles, gloves, hard hats, safety harnesses, etc.; provision of portable blower and sufficient hose; portable lighting equipment approved by the United States Bureau of Mines; and appropriately placed warning signs for slippery areas, nonpotable water fixtures, low head clearance areas, open service manhole, hazardous chemical storage areas, flammable fuel storage areas, etc.

(A) Hazardous Chemical Handling.

1. Containment materials. The materials utilized for storage, piping, valves, pumping, metering, splash guards, etc., shall be specially selected considering the physical and chemical characteristics of each hazardous or corrosive chemical.

2. Secondary containment. Chemical storage areas shall be enclosed in dikes or curbs which will contain the stored volume until it can be safely transferred to alternate storage or released to the wastewater at controlled rates which will not damage the facilities, inhibit the treatment process or contribute to stream pollution. Liquid polymer should be similarly contained to reduce areas with slippery floors, especially to protect travelways. Nonslip floor surfaces are desirable in polymer-handling areas.

3. Eye wash fountains and safety showers. Eye wash fountains and safety showers utilizing potable water shall be provided in the laboratory and on each floor level or work location involving hazardous or corrosive chemical storage, mixing (or slaking), pumping, metering or transportation unloading. These facilities are to be as close as practicable to possible chemical exposure sites and are to be fully useful during all weather conditions. The eye wash fountains shall be supplied with water of moderate temperature—fifty degrees to ninety degrees Fahrenheit (50°–90 °F) (ten degrees to thirty-two degrees Celsius (10°–32 °C)), separate from the hot water supply, suitable to provide fifteen to thirty (15–30) minutes of continuous irrigation of the eyes. The emergency showers shall be capable of discharging thirty to fifty gallons per day (30–50 gpm) (1.9–3.2 l/s) of water at moderate temperature at pressures of twenty to fifty pounds per square inch (20–50 psi) (1.41–3.52 kgf/cm^2). The eye wash fountains and showers shall be no more than twenty-five feet (25') (7.6 m) from points of hazardous chemical exposure.

4. Splash guards. All pumps or feeders for hazardous or corrosive chemicals shall have guards which will effectively prevent spray of chemicals into space occupied by personnel. The splash guards are in addition to guards to prevent injury from moving or rotating machinery parts.

5. Piping, labeling, coupling guards, location. All piping containing or transporting corrosive or hazardous chemicals shall be identified with labels every ten feet (10') (3.0 m) and with at least two (2) labels in each room, closet or pipe chase. Color coding may also be used but is not an adequate substitute for labeling. All connections (flanged or other type), except adjacent to storage or feeder areas, shall have guards which will

direct any leakage away from space occupied by personnel. Pipes containing hazardous or corrosive chemicals should not be located above shoulder level except where continuous drip collection trays and coupling guards will eliminate spray or dripping onto personnel.

6. Protective clothing and equipment. The following items of protective clothing or equipment shall be available and utilized for all operations or procedures where their use will minimize injury hazard to personnel: respirators, air supply type recommended for protection against chlorine; chemical workers' goggles or other suitable goggles (safety glasses are insufficient); face masks or shields for use over goggles; rubber gloves, rubber aprons with leg straps; rubber boots (leather and wool clothing should be avoided near caustics); and safety harness and line.

7. Warning system and signs. Facilities shall be provided for automatic shutdown of pumps and sounding of alarms when failure occurs in a pressurized chemical discharge line. Warning signs requiring use of goggles shall be located near chemical unloading stations, pumps and other points of frequent hazard.

8. Dust collection. Dust collection equipment shall be provided to protect personnel from dusts injurious to the lungs or skin and to prevent polymer dust from settling on walkways. The latter is to minimize slick floors which result when a polymer-covered floor becomes wet.

9. Container identification. The identification and hazard warning data included on shipping containers, when received shall appear on all containers (regardless of size or type) used to store, carry or use a hazardous substance. Sewage and sludge sample containers should be adequately labeled. Following is a suitable label for a sewage sample:

RAW SEWAGE

Sample point No.

Contains Harmful Bacteria.

May contain hazardous
or toxic material.

Do not drink or swallow.

Avoid contact with openings
or breaks in the skin.

AUTHORITY: section 644.026, RSMo Supp. 1989. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.150 Screening, Grit Removal and Flow Equalization

PURPOSE: The following criteria have been prepared as a guide for the design of screening, grit removal and flow equalization facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Screening Devices.

(A) Bar Racks and Screens.

1. When required. Protection for pumps and other equipment shall be provided by either coarse bar racks or bar screens. Protection for comminutors should be provided by coarse bar racks.

2. Location.

A. Indoors. Screening devices, installed in a building where other equipment or offices are located, should be accessible only through a separate outside entrance.

B. Outdoors. Screening devices installed outside shall be protected from freezing.

C. Access. Screening areas shall be provided with stairway access, adequate lighting and ventilation and a convenient and adequate means for removing the screenings.

3. Design and installation.

A. Bar spacing. Clear opening between bars should be no less than one inch (1") (2.54 cm) for manually cleaned screens. Clear openings for mechanically cleaned screens may be as small as five-eighths of an inch (5/8") (1.50 cm). Maximum clear openings should be one and three-fourths inches (1 3/4") (4.45 cm).

B. Slope. Manually cleaned screens, except those for emergency use, should be placed on a slope of thirty to forty-five degrees (35°–45°) on the horizontal.

C. Velocities. At normal operating flow conditions, approach velocities should be no less than 1.25 feet per second (38.1 cm/sec), to prevent settling; and no greater than 3.0 fps (91.4 cm/sec) to prevent forcing material through the openings.

D. Channels. Dual channels shall be provided and equipped with the necessary gates to isolate flow from any screening unit. Provisions shall also be made to facilitate dewatering each unit. The channel preceding and following the screen shall be shaped to eliminate stranding and settling of solids.

E. Invert. The screen channel invert should be three to six inches (3–6") (7.6–15.2 cm) below the invert of the incoming sewer.

F. Flow distribution. Entrance channels should be designed to provide equal and uniform distribution of flow to the screens.

G. Flow measurement. Flow measurement devices should be selected for reliability and accuracy. The effect of changes in backwater elevations, due to intermittent cleaning of screens, should be considered in locations of flow measurement equipment.

4. Safety.

Schedule JAM-5

A. Railings and gratings. Manually cleaned screen channels shall be protected by guard railings and deck gratings with adequate provisions for removal or opening to facilitate raking. Mechanically cleaned screen channels shall be protected by guard railings and deck gratings. Consideration should also be given to temporary access arrangements to facilitate maintenance and repair.

B. Mechanical devices. Mechanical screening equipment shall have adequate removal enclosures to protect personnel against accidental contact with moving parts and to prevent dripping in multi-level installations. A positive means of locking out each mechanical device shall be provided.

5. Control systems.

A. Timing devices. All mechanical units which are operated by timing devices shall be provided with auxiliary controls which will set the cleaning mechanism in operation at a pre-set high water elevation.

B. Electrical fixtures and controls. Electrical fixtures and controls in screening areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

C. Manual override. Automatic controls shall be supplemented by a manual override.

6. Disposal of screenings. Facilities must be provided for removal, handling, storage and disposal of screenings in a sanitary manner. Separate grinding of screenings and return to the sewage flow is unacceptable. Manually cleaned screening facilities should include an accessible platform from which the operator may rake screenings easily and safely. Suitable drainage facilities shall be provided for both the platform and storage areas.

7. Auxiliary screens. Where a single mechanically cleaned screen is used, an auxiliary manually cleaned screen shall be provided. Where two (2) or more mechanically cleaned screens are used, the design shall provide for taking any unit out-of-service without sacrificing the capability to handle the peak design flow.

(B) Fine Screens.

1. General. Fine screens may be used in lieu of primary sedimentation providing that subsequent treatment units are designed on the basis of anticipated screen performance. Fine screens should not be considered equivalent to primary sedimentation. Where fine screens are used, additional provisions for the removal of floatable oils and greases shall be considered.

2. Design. Tests should be conducted to determine BOD_5 and suspended solids removal efficiencies at the design peak hydraulic and peak organic loadings. A minimum of two (2) fine screens shall be provided; each unit being capable of independent operation. Capacity shall be provided to treat peak design flows with one (1) unit out-of-service. Fine screens shall be preceded by a mechanically cleaned bar screen or other protective device. Comminuting devices shall not be used ahead of fine screens.

3. Electrical fixtures and controls. Electrical fixtures and controls in screening areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

4. Servicing. Hosing equipment shall be provided to facilitate cleaning. Provisions shall be made for isolating or removing units from their location for servicing.

(4) Comminutors.

(A) General. Provisions for location shall be in accordance with screening devices, paragraph (3)(A)2. of this rule.

(B) When Required. Comminutors shall be used in plants that do not have primary sedimentation or fine screens and should be provided in cases where mechanically cleaned bar screens will not be used.

(C) Design Considerations.

1. Location. Comminutors should be located downstream of any grit removal equipment.

2. Size. Comminutor capacity shall be adequate to handle peak flows.

3. Installation. A screened bypass channel shall be provided. The use of the bypass channel should be automatic at depths of flow exceeding the design capacity for the comminutor. Each comminutor that is not preceded by grit removal equipment should be protected by a six inch (6.0") (15.2 cm) deep gravel trap. Gates shall be provided in accordance with subparagraph (3)(A)3.D. of this rule.

4. Servicing. Provisions shall be made to facilitate servicing units in place and removing units from their location for servicing.

5. Electrical controls and motors. Electrical equipment in comminutor chambers where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location). Motors in areas not governed by this requirement may need protection against accidental submergence.

(5) Grit Removal Facilities.

(A) When Required. Grit removal facilities should be provided for all sewage treatment plants; and are required for plants receiving sewage from combined sewers or from sewer systems receiving substantial amounts of grit. If a plant serving a separate sewer system is designed without grit facilities, the design shall include provisions for future installation. Consideration shall be given to possible damaging effects on pumps, comminutors and other preceding equipment and the need for additional storage capacity in treatment units where grit is likely to accumulate.

(B) Location.

1. General. Grit removal facilities should be located ahead of pumps and comminuting devices. Coarse bar racks should be placed ahead of grit removal facilities.

2. Housed facilities.

A. Ventilation. Uncontaminated air shall be introduced continuously at a rate of twelve (12) air changes per hour or intermittently at a rate of thirty (30) air changes per hour. Odor control facilities may also be warranted.

B. Access. Adequate stairway access to above or below grade facilities shall be provided.

C. Electrical. All electrical work in enclosed grit removal areas where hazardous gases may accumulate shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

3. Outside facilities. Grit removal facilities located outside shall be protected from freezing.

(C) Type and Number of Units. Plants treating wastes from combined sewers should have at least two (2) mechanically cleaned grit removal units with provisions for bypassing. A single manually cleaned or mechanically cleaned grit chamber with bypass is acceptable for small sewage treatment plants serving separate sanitary sewer systems. Minimum facilities for larger plants serving separate sanitary sewers should be at least one (1) mechanically cleaned unit with a bypass. Facilities other than channel-type are acceptable if provided with adequate and flexible controls for agitation and/or air supply devices and with grit collection and removal equipment.

(D) Design Factors.

1. General. The design effectiveness of a grit removal system shall be commensurate with the requirements of the subsequent process units.

2. Inlet. Inlet turbulence shall be minimized.

3. Velocity and detention. Channel-type chambers shall be designed to control velocities during normal variations in flow as close as possible to one foot (1') per second (30

cm/sec). The detention period shall be based on the size of particle to be removed. All grit removal facilities should be provided with adequate automatic control devices to regulate detention time, agitation or air supply.

4. Grit washing. The need for grit washing should be determined by the method of final grit disposal.

5. Drains. Provisions shall be made for isolating and de-watering each unit.

6. Water. An adequate supply of water under pressure shall be provided for cleanup.

7. Grit handling. Grit removal facilities located in deep pits should be provided with mechanical equipment for hoisting or transporting grit to ground level. Impervious nonslip working surfaces with adequate drainage shall be provided for grit handling areas. Grit transporting facilities shall be provided with protection against freezing and loss of material.

(6) Pre-aeration of sewage to reduce septicity may be required in special cases.

(7) Flow Equalization.

(A) General. Flow equalization can reduce the dry weather variations in organic and hydraulic loadings at any wastewater treatment plant. It should be provided where large diurnal variations are expected.

(B) Location. Equalization basins should be located downstream of pretreatment facilities such as bar screens, comminutors and grit chambers.

(C) Type. Flow equalization can be provided by using separate basins or on-line treatment units such as aeration tanks. Equalization basins may be designed as either in-line or side-line units. Unused treatment units, such as sedimentation or aeration tanks, may be utilized as equalization basins during the early period of design life.

(D) Size. Equalization basin capacity should be sufficient to effectively reduce expected flow and load variations to the extent deemed to be economically advantageous. With a diurnal flow pattern, the volume required to achieve the desired degree of equalization can be determined from a cumulative flow plot over the representative twenty-four (24)-hour period.

(E) Operation.

1. Mixing. Aeration or mechanical equipment shall be provided to maintain adequate mixing. Corner fillets and hopper bottoms with draw-offs should be provided to alleviate the accumulation of sludge and grit.

2. Aeration. Aeration equipment shall be sufficient to maintain a minimum of 1.0 mg/l of dissolved oxygen in the mixed basin contents at all times. Air supply rates should be a minimum of 1.25 cfm per one thousand gallons (1000 gal) (9 $l/min/m^3$) of storage capacity. The air supply should be isolated from other treatment plant aeration requirements to facilitate process aeration control. Standard process aeration supply equipment may be utilized as a source of standby aeration.

3. Controls. Inlets and outlets for all basin compartments shall be suitably equipped with accessible external valves, stop plates, weirs or other devices to permit flow control and the removal of an individual unit from service. Facilities shall also be provided to measure and indicate liquid levels and flow rates.

(F) Electrical. All electrical work in housed equalization basins shall be suitable for hazardous locations (National Electrical Code, Class I, Group D, Division 1 location).

(G) Access. Suitable access shall be provided to facilitate the maintenance of equipment and cleaning.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.160 Settling

*PURPOSE: The following criteria have been prepared as a guide for the design of settling tanks. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers **Recommended Standards for Sewage Works** and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, referred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) ($85.4m^3$) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) General Considerations.

(A) Number of Units. Multiple units capable of independent operation are desirable and shall be provided in all plants where design flows exceed one hundred thousand (100,000) gpd ($379m^3/d$). Plants not having multiple units shall include other provisions to assure continuity of treatment.

(B) Arrangement. Settling tanks shall be arranged in accordance with subsection 10 CSR 20-8.140(5)(E).

(C) Flow Distribution. Effective flow measurement devices and control appurtenances (that is, valves, gates, splitter boxes, etc.) shall be provided to permit proper proportion of flow to each unit.

(D) Tank Configuration. Consideration should be given to the probable flow pattern in the selection of tank size and shape, and inlet and outlet type and location.

(4) Design Considerations.

(A) Dimensions. The minimum length of flow from inlet to outlet should be ten feet (10') (3 m) unless special provisions are made to prevent short-circuiting. The sidewater depth for primary clarifiers shall be as shallow as practicable, but not less than seven feet (7') (2.1 m). Clarifiers following the activated sludge process shall have sidewater depths of at least twelve feet (12') (3.7 m) to

Schedule JAM-5

provide adequate separation zone between the sludge blanket and the overflow weirs. Clarifiers following fixed film reactors shall have sidewater depth of at least seven feet (7') (2.1m).

(B) Surface Settling Rates (Overflow Rates).

1. Primary settling tanks. Surface settling rates for primary tanks should not exceed one thousand (1000) gpd per square foot ($41m^3/m^2$/day) at design average flows or one thousand five hundred (1500) gpd per square foot ($61m^3m^2$/day) for peak hourly flows. Clarifier sizing shall be calculated for both flow conditions and the larger surface area determined shall be used. Primary settling of normal domestic sewage can be expected to remove thirty to fifty percent (30–50%) of the influent BOD. However, anticipated BOD removal for sewage containing appreciable quantities of industrial wastes (or chemical additions to be used) should be determined by laboratory tests and consideration of the quantity and character of the wastes.

2. Intermediate settling tanks. Surface settling rates for intermediate settling tanks following series units of fixed film reactor processes shall not exceed one thousand five hundred (1500) gpd per square foot ($61m^3/m^2$/day) based on peak hourly flow.

3. Final settling tanks. Settling tests should be conducted wherever pilot study of biological treatment is warranted by unusual waste characteristics or treatment requirements. Testing shall be done where proposed loadings go beyond the limits set forth in this section. Surface settling rates for settling tanks following trickling filters or rotating biological contractors shall not exceed one thousand two hundred (1200) gpd per square foot ($49m^3/m^2$/day) based on peak hourly flow. Final settling tanks following activated sludge processes must be designed to meet thickening as well as solids separation requirements. Since the rate of recirculation of return sludge from the final settling tanks to the aeration or re-aeration tanks is quite high in activated sludge processes, surface settling rate and weir overflow rate should be adjusted for the various processes to minimize the problems with sludge loadings, density currents, inlet hydraulic turbulence and occasional poor sludge settleability. The hydraulic design of intermediate and final settling tanks following activated sludge processes shall be based upon the anticipated peak hourly rate for the area downstream of the inlet baffle. The hydraulic loadings shall not exceed—one thousand two hundred (1200) gpd per square foot ($49m^3/m^2$/day) for conventional, step aeration, contact stabilization and the carbonaceous stage of separate-stage nitrification; one thousand (1000) gpd per square foot ($41m^3/m^2$/day) for extended aeration; and eight hundred (800) gpd per square foot ($33m^3/m^2$/day) for the separate nitrification stage. The solids loading for all activated sludge processes shall not exceed fifty pounds (50 lbs.) solids per day per square foot (244 kg/m^2/day) at the peak rate. Consideration should be given to flow equalization.

(C) Inlet Structures. Inlets should be designed to dissipate the inlet velocity, to distribute the flow equally both horizontally and vertically and to prevent short-circuiting. Channels should be designed to maintain a velocity of at least one foot (1') per second (0.3m/s) at one-half (1/2) the design flow. Corner pockets and dead ends should be eliminated and corner fillets or channeling used where necessary. Provisions shall be made for elimination or removal of floating materials in inlet structures.

(D) Weirs.

1. General. Overflow weirs shall be adjustable for leveling.

2. Location. Overflow weirs shall be located to optimize actual hydraulic detention time, and minimize short-circuiting.

3. Design rates. Weir loadings should not exceed ten thousand (10,000) gpd per lineal foot ($124m^3$/m/day) for plants designed for average flows of 1.0 mgd ($3,785m^3$/day) or less. Higher weir loadings may be used for plants designed for larger average flows but should not exceed fifteen thousand (15,000) gpd per lineal foot ($186m^3$/m/day). If pumping is required, weir loadings should be related to pump delivery rates to avoid short-circuiting.

4. Weir troughs. Weir troughs shall be designed to prevent submergence at maximum design flow and to maintain a velocity of at least one foot (1') per second (0.3m/s) at one-half (1/2) the design flow.

(E) Submerged Surfaces. The tops of troughs, beams and similar submerged construction elements shall have a minimum slope of 1.4:1; the underside of the elements should have a slope of one to one (1:1) to prevent the accumulation of scum and solids.

(F) Unit De-watering. Unit de-watering features shall conform to the provisions outlined in 10 CSR 20-8.140(6). The unit isolation design should also provide for redistribution of the plant flow to the remaining units.

(G) Freeboard. Walls of settling tanks shall extend at least six inches (6") (15 cm) above the surrounding ground surface and shall provide not less than twelve inches (12") (30 cm) freeboard. Additional freeboard or the use of wind screens is recommended where larger settling tanks are subject to high velocity wind currents that would cause tank surface waves and inhibit effective scum removal.

(5) Sludge and Scum Removal.

(A) Scum Removal. Effective scum collection and removal facilities, including baffling, shall be provided for all settling tanks. The unusual characteristics of scum which may adversely affect pumping, piping, sludge handling and disposal should be recognized in design. Provisions may be made for the discharge of scum with the sludge; however, other special provisions for disposal may be necessary.

(B) Sludge Removal. Sludge collection and withdrawal facilities shall be so designed as to assure rapid removal of the sludge. Suction withdrawal should be provided for activated sludge plants designed for reduction of the nitrogenous oxygen demand and is encouraged for those plants designed for carbonaceous oxygen demand reduction.

1. Sludge hopper. The minimum slope of the side walls shall be 1.7:1. Hopper wall surfaces should be made smooth with rounded corners to aid in sludge removal. Hopper bottoms shall have a maximum dimension of two feet (2') (.6m). Extra depth sludge hoppers for sludge thickening are not acceptable.

2. Cross-collectors. Cross-collectors serving one (1) or more settling tanks may be useful in place of multiple sludge hoppers.

3. Sludge removal piping. Each hopper shall have an individually-valved sludge withdrawal line at least six inches (6") (15 cm) in diameter. The static head available for withdrawal of sludge shall be thirty inches (30") (76 cm) or greater as necessary to maintain a three-foot (3') per second (0.9m/s) velocity in the withdrawal pipe. Clearance between the end of the withdrawal line and the hopper walls shall be sufficient to prevent bridging of the sludge. Adequate provisions shall be made for rodding or back-flushing individual pipe runs. Piping shall also be provided to return waste sludge to primary clarifiers.

4. Sludge removal control. Sludge wells equipped with telescoping valves or other appropriate equipment shall be provided for viewing, sampling and controlling the rate of sludge withdrawal. The use of easily maintained sight glass and sampling valves may be appropriate. A means of measuring the sludge removal rate shall be provided. Air lift type of sludge removal will not be approved for removal of primary sludges. Sludge pump motor control system shall include time clocks and valve activators for regulating the duration and sequencing of sludge removal.

(6) Protective and Service Facilities.

(A) Operator Protection. All settling tanks shall be equipped to enhance safety for operators. These features shall appropriately include machinery covers, life lines, stairways, walkways, hand rails and slip-resistant surfaces.

(B) Mechanical Maintenance Access. The design shall provide for convenient and safe access to routine maintenance items such as gear boxes, scum removal, mechanism and baffles, weirs, inlet stilling baffle area and effluent channels.

(C) Electrical Fixtures and Controls. Electrical fixtures and controls in enclosed settling basins shall be suitable for hazardous locations (National Electrical Code for Class I, Group D, Division 1 location). The fixtures and controls shall be located so as to provide convenient and safe access for operation and maintenance. Adequate area lighting shall be provided.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.170 Sludge Handling and Disposal

PURPOSE: The following criteria have been prepared as a guide for the design of sludge handling and disposal facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers, ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

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(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) ($85.4m^3$) or less (see 10 CSR 20-8.020) for the requirements for those facilities.

(3) Design Considerations. The selection of sludge handling and disposal methods should include the following considerations: energy requirements; efficacy of sludge thickening; complexity of equipment; staffing requirements; toxic effects of heavy metals and other substances on sludge stabilization and disposal; treatment of side-stream flow such as digester and thickener supernatant; a back-up method of sludge handling and disposal; and methods of ultimate sludge disposal.

(4) Sludge Thickeners. As the first step of sludge handling, the need for sludge thickeners to reduce the volume of sludge should be considered. The design of thickeners (gravity, dissolved air flotation, centrifuge and others) should consider the type and concentration of sludge, the sludge stabilization processes, the method of ultimate sludge disposal, chemical needs and the cost of operation. Particular attention should be given to the pumping and piping of the concentrated sludge and possible onset of anaerobic conditions. Sludge should be thickened to at least five percent (5%) solids prior to transmission to digesters.

(5) Anaerobic Sludge Digestion.

(A) General.

1. Multiple units. Multiple tanks are recommended. Where a single digestion tank is used, an alternate method of sludge processing or emergency storage to maintain continuity of service shall be provided.

2. Depth. For those units proposed to serve as supernatant separation tanks, the depth should be sufficient to allow for the formation of a reasonable depth of supernatant liquor. A minimum sidewater depth of twenty feet (20') (6.10 m) is recommended.

3. Maintenance provisions. To facilitate draining, cleaning and maintenance, the following features are desirable:

A. Slope. The tank bottom should slope to drain toward the withdrawal pipe. For tanks equipped with a suction mechanism for withdrawal of sludge, a bottom slope of one to twelve (1:12) or greater is recommended. Where the sludge is to be removed by gravity alone, one to four (1:4) slope is recommended.

B. Access manholes. At least two (2) thirty-six inch (36") (91 cm) diameter access manholes should be provided in the top of the tank in addition to the gas dome. There should be stairways to reach the access manholes. A separate sidewall manhole shall be provided. The opening should be large enough to permit the use of mechanical equipment to remove grit and sand.

C. Safety. Nonsparking tools, safety lights, rubber-soled shoes, safety harness, gas detectors for inflammable and toxic gases, and at least two (2) self-contained breathing units shall be provided for emergency use.

(B) Sludge Inlets and Outlets. Multiple recirculation withdrawal and return points should be provided to enhance flexible operation and effective mixing, unless mixing facilities are incorporated within the digester. The returns, in order to assist in scum breakup, should discharge above the liquid level and be located near the center of the tank. Raw sludge discharge to the digester should be through the sludge heater and recirculation return piping or directly to the tank if internal mixing facilities are provided. Sludge withdrawal to disposal should be from the bottom of the tank. This pipe should be interconnected with the recirculation piping to increase versatility in mixing the tank contents, if the piping is provided. Sludge withdrawal should be at the bottom of the tank.

(C) Tank Capacity. The total digestion tank capacity should be determined by rational calculations based upon such factors as volume of sludge added, its percent solids and character, the temperature to be maintained in the digesters, the degree or extent of mixing to be obtained and the degree of volatile solids reduction required. Calculations should be submitted to justify the basis of design. When the calculations are not based on these factors,

Schedule JAM-5

the minimum combined digestion tank capacity outlined in paragraphs (5)(C)1. and 2. will be required. The requirements assume that a raw sludge is derived from ordinary domestic wastewater, that a digestion temperature is to be maintained in the range of ninety degrees to one hundred degrees Fahrenheit (90°–100 °F) (32.2 °C–37.8 °C), that forty to fifty percent (40–50%) volatile matter will be maintained in the digested sludge, and that the digested sludge will be removed frequently from the system (see also paragraph (5)(A)1. of this rule).

1. Completely-mixed systems. Completely-mixed systems shall provide for intimate and effective mixing to prevent stratification and to assure homogeneity of digester content. The system may be loaded at a rate up to eighty pounds (80 lbs.) of volatile solids per one thousand (1000) cubic feet of volume per day (1.28 kg/m^3/day) in the active digestion units. When grit removal facilities are not provided, the reduction of digester volume due to grit accumulation should be considered. Complete mixing can be accomplished only with substantial energy input.

2. Moderately-mixed systems. For digestion systems where mixing is accomplished only by circulating sludge through an external heat exchanger, the system may be loaded at a rate up to forty pounds (40 lbs.) of volatile solids per one thousand (1000) cubic feet of volume per day (0.64 kg/m^3/day) in the active digestion units. This loading may be modified upward or downward depending upon the degree of mixing provided. Provisions for mixing scum shall be included.

(D) Gas Collection, Piping and Appurtenances.

1. General. All portions of the gas system, including the space above the tank liquor, storage facilities and piping, shall be so designed that under all normal operating conditions, including sludge withdrawal, the gas will be maintained under positive pressure. All enclosed areas where any gas leakage might occur shall be adequately ventilated.

2. Safety equipment. All necessary safety facilities shall be included where gas is produced. Pressure and vacuum relief valves and flame traps, together with automatic safety shutoff valves, shall be provided. Water seal equipment shall not be installed. Gas safety equipment and gas compressors should be housed in a separate room with an exterior entrance.

3. Gas piping and condensate. Gas piping shall be of adequate diameter and shall slope to condensate traps at low points. The use of float-controlled condensate traps is not permitted.

4. Gas utilization equipment. Gas-fired boilers for heating digesters shall be located in a separate room not connected to the digester gallery. The separated room would not ordinarily be classified as hazardous location. Gas lines to these units shall be provided with suitable flame traps.

5. Electrical fixtures. Electrical fixtures and controls in places enclosing anaerobic digestive appurtenances where hazardous gases are normally contained in the tanks and/or piping shall comply with the National Electrical Code, Class I, Group D, Division 2 locations. Digester galleries should be isolated from normal operating areas to avoid an extension of the hazardous location in accordance with paragraph (5)(D)7. of this rule.

6. Waste gas. Waste gas burners shall be readily accessible and should be located at least twenty-five feet (25') (7.6 m) away from any plant structure if placed at ground level or may be located on the roof of the control building if sufficiently removed from the tank. All waste gas burners shall be equipped with automatic ignition, such as pilot light or a device using a photoelectric cell sensor. Consideration should be given to the use of natural or propane gas to insure reliability of the pilot light. In remote locations it may be permissible to discharge the gas to the atmosphere through a return-bend screened vent terminating at least ten feet (10') (3 m) above the ground surface, provided that the assembly incorporates a flame trap.

7. Ventilation. Any underground enclosures connecting with digestion tanks or containing sludge or gas piping or equipment shall be provided with forced ventilation in accordance with 10 CSR 20-8.130(4)(G) and 10 CSR 20-8.130(4)(G)2. The piping gallery for digesters should not be connected to other passages. Where used, tightly fitting, self-closing doors should be provided at connecting passageways and tunnels to minimize the spread of gas.

8. Meter. A gas meter with bypass shall be provided to meter total gas production.

(E) Digester Heating.

1. Insulation. Wherever possible digestion tanks should be constructed above groundwater level and should be suitably insulated to minimize heat loss.

2. Heating facilities. Sludge may be heated by circulating the sludge through external heaters or by heating units located inside the digestion tank.

A. External heating. Piping shall be designed to provide for the preheating of feed sludge before introduction to the digesters. Provisions shall be made in the layout of the piping and valving to facilitate cleaning of these lines. Heat exchanger sludge piping should be sized for heat transfer requirements.

B. Other heating methods. Other types of heating facilities will also be considered on their own merits.

3. Heating capacity. Heating capacity sufficient to consistently maintain the design sludge temperature shall be provided. Where digester tank gas is used for sludge heating, an auxiliary fuel supply is required.

4. Hot water internal heating controls.

A. Mixing valves. A suitable automatic mixing valve shall be provided to temper the boiler water with return water so that the inlet water to the heat jacket can be held below a temperature at which caking will be accentuated. Manual control should also be provided by suitable bypass valves.

B. Boiler controls. The boiler should be provided with suitable automatic controls to maintain the boiler temperature at approximately one hundred eighty degrees Fahrenheit (180 °F) (82 °C) to minimize corrosion and to shut off the main gas supply in the event of pilot burner or electrical failure, low boiler water level or excessive temperature.

C. Thermometers shall be provided to show temperatures of the sludge, hot water feed, hot water return and boiler water.

(F) Supernatant Withdrawal.

1. Piping size. Supernatant piping should not be less than six inches (6") (15 cm) in diameter.

2. Withdrawal arrangements.

A. Withdrawal levels. Piping should be arranged so that withdrawal can be made from three (3) or more levels in the digester. A positive unvalved vented overflow shall be provided.

B. Supernatant selector. If a supernatant selector is provided, provisions shall be made for at least one (1) other draw-off level located in the supernatant zone of the tank in addition to the unvalved emergency supernatant draw-off pipe. High pressure backwash facilities shall be provided.

3. Sampling. Provisions should be made for sampling at each supernatant draw-off level. Sampling pipes should be at least one and one-half inches (1 1/2") (3.8 cm) in diameter and should terminate at a suitably-sized sampling sink or basin.

4. Alternate supernatant disposal. Consideration should be given to supernatant conditioning where appropriate in relation to its effect on plant performance and effluent quality.

(6) Aerobic Sludge Digestion.

(A) General. Aerobic digestion can be used to stabilize primary sludge, secondary sludge or a combination of the two. Digestion is accomplished in single or multiple tanks designed to provide effective air mixing, reduction of the organic matter, supernatant separation and sludge concentration under controlled conditions.

1. Digestion tanks. Multiple tanks are recommended. A single sludge digestion tank may be used in the case of small treatment plants or where adequate provision is made for sludge handling where a single unit will not adversely affect normal plant operations.

(B) Mixing and Air Requirements. Aerobic sludge digestion tanks shall be designed for effective mixing by satisfactory aeration equipment. Sufficient air shall be provided to keep the solids in suspension and maintain dissolved oxygen between one and two (1–2) mg/l. A minimum mixing and oxygen requirement of thirty (30) cfm per one thousand (1000) cubic feet of tank volume (30 l/min/m^3) shall be provided with the largest blower out-of-service. If diffusers are used, the nonclog type is recommended, and they should be designed to permit continuity of service. If mechanical aerators are utilized, a minimum of 1.0 horsepower per one thousand (1000) cubic feet (28.3m^3) should be provided. Use of mechanical equipment is discouraged where freezing temperatures are normally expected.

(C) Tank Capacity. The determination of tank capacities shall be based on rational calculations, including such factors as quantity of sludge produced, sludge characteristics, time of aeration and sludge temperature.

1. Volatile solids loading. It is recommended that the volatile suspended solids loading not exceed one hundred pounds per one thousand cubic feet (100 lb/1000 ft^3) of volume per day (1.60 kg/m^3/day) in the digestion units. Lower loading rates may be necessary depending on temperature, type of sludge and other factors.

2. Solids retention time. Required minimum solids retention time for stabilization of biological sludges vary depending on type of sludge. Normally, a minimum of fifteen (15) days' retention should be provided for waste activated sludge and twenty (20) days for combination of primary and waste activated sludge, or primary sludge alone. Where sludge temperature is lower than fifty degrees Fahrenheit (50 °F) (10 °C), additional detention time should be considered.

(D) Supernatant Separation. Facilities shall be provided for effective separation and withdrawal of supernatant and for effective collection and removal of scum and grease.

(7) Sludge Pumps and Piping.

(A) Sludge Pumps.

1. Capacity. Pump capacities should be adequate but not excessive. Provision for varying pump capacity is desirable.

2. Duplicate units. Duplicate units shall be provided where failure of one (1) unit would seriously hamper plant operation.

3. Type. Plunger pumps, screw feed pumps, recessed impeller type centrifugal pumps, progressive cavity pumps or other types of pumps with demonstrated solids handling capability shall be provided for handling raw sludge. Where centrifugal pumps are used, a parallel plunger type pump should be provided as an alternate to increase reliability of the centrifugal pump.

4. Minimum head. A minimum positive head of twenty-four inches (24") (61 cm) shall be provided at the suction side of centrifugal type pumps and is desirable for all types of sludge pumps. Maximum suction lifts should not exceed ten feet (10') (3m) for plunger pumps.

5. Sampling facilities. Unless sludge sampling facilities are otherwise provided, quick closing sampling valves shall be installed at the sludge pumps. The size of valve and piping should be at least one and one-half inches (1 1/2") (3.8 cm).

(B) Sludge Piping.

1. Size and head. Sludge withdrawal piping should have a minimum diameter of eight inches (8") (20.3 cm) for gravity withdrawal and six inches (6") (15.2 cm) for pump suction and discharge lines. Where withdrawal is by gravity the available head on the discharge pipe should be adequate to provide at least three feet (3') per second (0.9m/sec) velocity.

2. Slope. Gravity piping should be laid on uniform grade and alignment. The slope of gravity discharge piping should not be less than three percent (3%). Provisions should be made for cleaning, draining and flushing discharge lines.

3. Supports. Special consideration should be given to the corrosion resistance and continuing stability of supporting systems located inside the digestion tank.

(8) Sludge De-watering.

(A) Sludge Drying Beds.

1. Area. In determining the area of sludge drying beds, consideration shall be given to climatic conditions, the character and volume of the sludge to be de-watered, the method and schedule of sludge removal and other methods of sludge disposal. (It should be recognized that, in northern areas of the country, the drying season is only six (6) months a year.) In general, the sizing of the drying bed may be estimated on the basis of 2.0 ft^2/capita (0.2 m^2/capita) when the drying bed is the primary method of de-watering, and 1.0 ft^2/capita (0.1 m^2/capita) if it is to be used as a back-up de-watering unit. An increase of bed area by twenty-five percent (25%) is recommended for paved-type bed.

2. Percolation type. The lower course of gravel around the underdrains should be properly graded and should be twelve inches (12") (30 cm) in depth, extending at least six inches (6") (15.2 cm) above the top of the under drains. It is desirable to place this in two (2) or more layers. The top layer of at least three inches (3") (7.6 cm) should consist of gravel one-eighth inch (1/8") to one-fourth inch (1/4") (3.2–6.4 mm) in size.

A. Sand. The top course should consist of at least six to nine inches (6"–9") (15–23 cm) of clean coarse sand. The finished sand surface should be level.

B. Underdrains. Underdrains should be clay pipe or concrete drain tile at least four inches (4") (10 cm) in diameter laid with open joints. Underdrains should be spaced not more than twenty feet (20') (6 m) apart. As to the discharge of the underdrain filtrate, refer to subsection (8)(C) of this rule.

3. Partially paved type. The partially paved type drying bed should be designed with consideration for space requirement to operate mechanical equipment for removing the dried sludge.

4. Walls. Walls should be watertight and extend fifteen to eighteen inches (15"–18") (38 cm–46 cm) above and at least six inches (6") (15 cm) below the surface. Outer walls should be curbed to prevent soil from washing onto the beds.

5. Sludge removal. Not less than two (2) beds should be provided and they should be arranged to facilitate sludge removal. Concrete truck tracks should be provided for all percolation type sludge beds. Pairs of tracks for percolation type should be on twenty-foot (20') (6 m) centers.

6. Sludge influent. The sludge pipe to the drying beds should terminate at least twelve inches (12") (30 cm) above the surface and be so arranged that it will drain. Concrete splash plates for percolation type should be provided at sludge discharge points.

7. Protective enclosure. A protective enclosure shall be provided if winter operation is required.

(B) Mechanical De-watering Facilities. Provision shall be made to maintain sufficient continuity of service so that sludge may be de-watered without accumulation beyond storage capacity. The number of vacuum filters, centrifuges, filter presses, belt filters or other mechanical de-watering facilities should be sufficient to de-water the sludge produced with one (1) largest unit out-of-service. Unless other standby facilities are available, adequate storage facilities shall be provided. The storage capacity should be sufficient to handle at least a three (3)-month sludge production.

1. Auxiliary facilities per vacuum filters. There shall be a back-up vacuum pump and filtrate pump installed for each vacuum filter. It is permissible to have an uninstalled back-up vacuum pump or filtrate pump for every three (3) or less vacuum filters, provided that the installed unit can easily be removed and replaced.

2. Ventilation. Adequate facilities shall be provided for ventilation of de-watering area. The exhaust air should be properly conditioned to avoid odor nuisance.

3. Chemical handling enclosures. Lime-mixing facilities should be completely enclosed to prevent the escape of lime dust. Chemical handling equipment should be automated to eliminate the manual lifting requirement.

(C) Drainage and Filtrate Disposal. Drainage from beds or filtrate from de-watering units shall be returned to the sewage treatment process at appropriate points.

(D) Other De-watering Facilities. If it is proposed to de-water or dispose of sludge by other methods, a detailed description of the process and design data shall accompany the plans.

(9) Municipal Sludge Disposal on Land. The program of land spreading of sludge must be evaluated as an integral system which include stabilization, storage, transportation, application, soil, crop and groundwater. The following guidelines were formulated to provide the criteria of municipal sludge disposal on land. Sewage sludge is useful to crop and soil by providing nutrients and organic matter. Sewage sludge contains heavy metals and other substances which could affect soil productivity and the quality of food. Sufficient information is not available to completely evaluate the deleterious effects. The purpose of the guidelines is to indicate the acceptable method of sludge disposal on land surface based on current knowledge. It is recognized that these guidelines should be revised as more information becomes available.

(A) General Limitations to be Observed.

1. Stabilized sludge. Only stabilized sludge shall be surface applied to farmland or pasture. Stabilized sludge is defined as processed sludge in which the organic and bacterial contents of raw sludge are reduced to levels deemed necessary by the agency to prevent nuisance odors and public health hazards. Any process which produces sludge equivalent in quality to the above in terms of public health factors and odor potential may be accepted. Additional treatment would be required to further reduce pathogens when the sludge is to be spread on dairy pastures and other crops which are in the human food chain.

2. Raw vegetables. Sludge should not be applied to land which is used for growing food crops to be eaten raw, such as leafed vegetables and root crops.

3. Minimum pH. No sludge shall be applied on land if the soil pH is less than 6.5 when sludge is applied and pH shall be maintained above 6.5 for at least two (2) years following end of sludge application.

4. Persistent organic chemicals. At present time, sufficient information is not available to establish criteria of sludge spreading in regard to persistent organic chemicals, such as pesticides and polychlorinated biphenyls (PCB). However, if there is a known source in the sewer service area which discharges or discharged in the past such chemicals, the sludge should be analyzed for chemicals and the agency shall be consulted for recommendations concerning sludge spreading.

(B) Site Selection. By proper selection of the sludge application site, the nuisance potential and public health hazard should be minimized. The following items should be considered and the agency should be consulted for specific limits: land ownership information; groundwater table and bedrock location; location of dwellings, road and public access; location of wells, springs, creeks, streams and flood plains; slope of land surface; soil characteristics; climatological information and periods of ground freezing; land use plan; and road weight restrictions.

(C) Sludge Application on Farmland. Heavy metal loading to land should be limited in order to avoid reduction of soil productivity. A detailed chemical analysis of the sludge shall be made and the application rate shall be based on characteristics of the application site and crop uptake. The agency shall be contacted for specific limits.

(D) Sludge Application on Forested Land. Disposal of sludge on forested land is considerably less hazardous than on cropland in terms of heavy metal toxicity unless the land is to be converted to cropland. For the allowable sludge loading the agency should be consulted.

(E) Management of Spreading Operation.

1. Hauling equipment. The sludge hauling equipment should be designed to prevent spillage, odor and other public nuisance.

2. Valve control. The spreading tank truck should be provided with a control so that the discharge valve can be opened and closed by the driver while the vehicle is in motion. The spreading valve should be of the fail-safe type (that is, self-closing) or an additional manual standby valve should be employed to prevent uncontrolled spreading or spillage.

3. Sludge storage. Sufficient sludge storage capacity shall be provided for periods of inclement weather and equipment failure. The storage facilities shall be designed, located and operated so as to avoid nuisance conditions.

4. Spreading methods. The selection of spreading methods depends on the sludge characteristics, environmental factor and others. When control of odor nuisance and runoff is required, immediate incorporation of sludge after spreading or subsurface injection should be considered. When such method is utilized, an adjustment in the reduced rate of ammonia loss into the atmosphere should be considered in the computation for nitrogen balance. The sewage sludge should be spread uniformly over the surface when tank truck spreading, ridge and furrow irrigation or other methods are used. Proposals for subsurface application of sludge shall include for review a description of the equipment and program for application. Spray systems except for downward directed types will not ordinarily be approved.

5. Boundary demarcation. The boundaries of the site shall be marked (for example, with stakes at corners) so as to avoid confusion regarding the location of the site during the sludge application. The markers should be maintained until the end of the current growing season.

6. Public access. Public access of the disposal site must be controlled by either positive barriers or remoteness of the site.

(F) Monitoring and Reporting. The requirement of the agency on the monitoring and reporting of sludge spreading operation should be followed. As a minimum, the producer of sludge should regularly collect and record information on the sludge and soil characteristics and volume of sludge spread to a particular site.

(10) Other Sludge Disposal Methods. When other sludge disposal methods, such as incineration and landfill, are considered, pertinent requirements from the agency shall be followed.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

Schedule JAM-5

10 CSR 20-8.180 Biological Treatment

PURPOSE: The following criteria have been prepared as a guide for the design of biological treatment facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that the name can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Trickling Filters.

(A) General. Trickling filters may be used for treatment of sewage amenable to treatment by aerobic biologic processes. Trickling filters shall be preceded by effective settling tanks equipped with scum and grease collecting devices or other suitable pretreatment facilities. Filters shall be designed so as to provide the reduction in carbonaceous and/or nitrogenous oxygen demand in accordance with 10 CSR 20-7.015, Effluent Regulations and 10 CSR 20-7.031, Water Quality Standards, or to properly condition the sewage for subsequent treatment processes.

(B) Hydraulics.

1. Distribution.

A. Uniformity. The sewage may be distributed over the filter by rotary distributors or other suitable devices which will ensure uniform distribution to the surface area. At design average flow, the deviation from a calculated uniformly distributed volume per square foot (m^2) of the filter surface shall not exceed plus or minus ten percent (±10%) at any point. All hydraulic factors involving proper distribution of sewage on the filters shall be submitted to the agency.

B. Head requirements. For reaction type distributions, a minimum head of twenty-four inches (24") (61 cm) between low water level in siphon chamber and center of arms is required. Similar allowance in design shall be provided for added pumping head requirements where pumping to the reaction type distributor is used.

C. Clearance. A minimum clearance of six inches (6") (15 cm) between media and distributor arms shall be provided. Greater clearance is essential where icing may occur.

2. Dosing. Sewage may be applied to the filters by siphons, pumps or by gravity discharge from preceding treatment units when suitable flow characteristics have been developed. Application of the sewage shall be practically continuous. The piping system shall be designed for recirculation.

3. Piping system. The piping system including dosing equipment and distributor shall be designed to provide capacity for the peak hourly flow rate including recirculation required under paragraph (3)(E)5. of this rule.

(C) Media.

1. Quality. The media may be crushed rock, slag or specially manufactured material. The media shall be durable, resistant to spalling or flaking and be relatively insoluble in sewage. The top eighteen inches (18") (46 cm) shall have a loss by the twenty (20)-cycle, sodium sulfate soundness test of not more than ten percent (10%), as prescribed by the *ASCE Manual of Engineering Practice*, Number 13; the balance is to pass a ten (10)-cycle test using the same criteria. Slag media shall be free from iron. Manufactured media shall be resistant to ultraviolet degradation, disintegration, erosion, aging, all common acids and alkalies, organic compounds and fungus and biological attack. Media shall be either structurally capable of supporting a man's weight or a suitable access walkway provided to allow for distributor maintenance.

2. Depth. Rock and/or slag filter media shall have a minimum depth of five feet (5') (1.5 m) above the underdrains. Manufactured filter media should have a minimum depth of ten feet (10') (3m) to provide adequate contact time with the wastewater. Rock and/or slag filter media depths shall not exceed ten feet (10') (3m) and manufactured filter media depths shall not exceed thirty feet (30') (9.1m) except where special construction is justified through extensive pilot studies.

3. Size and grading of media.

A. Rock, slag and similar media. Rock, slag and similar media shall not contain more than five percent (5%) by weight of pieces whose longest dimension is three (3) times the least dimension. They shall be free from thin elongated and flat pieces, dust, clay, sand or fine material and shall conform to the following size and grading when mechanically graded over vibrating screen with square openings.

Passing 4 1/2-inch (4 1/2") screen (11.4 cm)—one hundred percent (100%) by weight.

Retained on 3-inch (3") screen (7.6 cm)—ninety-five to one hundred percent (95–100%) by weight.

Passing 2-inch (2") screen (5.1 cm)—0.2% by weight.

Passing 1-inch (1") screen (2.5 cm)—0.1% by weight.

B. Manufactured Media. Suitability will be evaluated on the basis of experience with installations handling similar wastes and loadings.

C. Handling and placing of media. Material delivered to the filter site shall be stored on wood planks or other approved clean hard surfaced areas. All material shall be rehandled at the filter site and no material shall be dumped directly into the filter. Crushed rock, slag and similar media shall be washed and rescreened or forked at the filter site to remove all fines. The material shall be placed by hand to a depth of twelve inches (12") (30 cm) above the tile underdrains and the remainder of material may be placed by means of belt conveyors or equally effective methods approved by the engineer. All material shall be carefully placed so as not to damage the underdrains. Manufactured media shall be handled and placed as approved by the engineer. Trucks, tractors or other heavy equipment shall not be driven over the filter during or after construction.

(D) Underdrainage System.

1. Arrangement. Underdrains with semicircular inverts or equivalent should be provided and the underdrainage system shall cover the entire floor of the filter. Inlet openings into the underdrains shall have an unsubmerged gross combined area equal to at least fifteen percent (15%) of the surface area of the filter.

2. Hydraulic capacity and ventilation. The underdrains shall have a minimum slope of one percent (1%). Effluent channels shall be designed to produce a minimum velocity of two feet (2') per second (0.61m/s) at average daily rate of application to the filter. The underdrainage system, effluent channels and effluent pipe shall be designed to permit free passage of air. The size of drains, channels and pipe should be so that not more than fifty percent (50%) of their cross section area will be submerged under the design peak hydraulic loading, including proposed or possible future or recirculated flows. Consideration shall be given to the use of forced ventilation, particularly for covered filters and deep manufactured media filters.

3. Flushing. Provision should be made for flushing the underdrains. In small filters, use of a peripheral head channel with vertical vents is acceptable for flushing purposes. Inspection facilities should be provided.

(E) Special Features.

1. Flooding. Appropriate valves, sluice gates or other structures shall be provided so as to enable flooding of filters comprised of rock or slag media for filter fly control.

2. Freeboard. A freeboard of four feet (4') (1.2 m) or more should be provided for tall, manufactured media filters to maximize the containment of windblown spray.

3. Maintenance. All distribution devices, underdrains, channels and pipes shall be installed so that they may be properly maintained, flushed or drained.

4. Winter protection. Adequate protection such as covers in severe climate or wind breaks in moderate climates shall be provided to maintain operation and treatment efficiencies when climatic conditions are expected to result in problems due to cold temperatures.

5. Recirculation. The piping system shall be designed for recirculation as required to achieve the design efficiency. The recirculation rate shall be variable and subject to plant operator control.

6. Recirculation measurement. Devices shall be provided to permit measurement of the recirculation rate. Time lapse meters and pump head recording devices are acceptable for facilities treating less than one million gallons per day (1 mgd) (3785m^3/d).

(F) Rotary Distributor Seals. Mercury seals shall not be permitted. Ease of seal replacement shall be considered in the design to ensure continuity of operation.

(G) Multi-Stage Filters. The foregoing standards also apply to all multi-stage filters.

(H) Unit Sizing. Required volumes of rock or slag media filters shall be based upon pilot testing with the particular wastewater or any of the various empirical design equations that have been verified through actual full scale experience. Calculations must be submitted if pilot testing is not utilized. Pilot testing is recommended to verify performance predictions based upon the various design equations, particularly when significant amounts of industrial wastes are present. Expected performance of filters packed with manufactured media shall be determined from documented full scale experience at similar installation or through actual use of a pilot plant on-site.

(I) Design Safety Factors. Trickling filters are affected by diurnal load conditions. The volume of media determined from either pilot plant studies or use of acceptable design equations shall be based upon the design peak hourly organic loading rate rather than the average rate. An alternative would be to provide flow equalization.

(4) Activated Sludge.

(A) General.

1. Applicability.

A. Biodegradable wastes. The activated sludge process and its various modifications may be used where sewage is amenable to biological treatment.

B. Operational requirement. This process requires close attention and competent operating supervision, including routine laboratory control. These requirements shall be considered when proposing this type of treatment.

C. Energy requirement. This process requires major energy usage to meet aeration demands. Energy costs and potential mandatory emergency public power reduction events in relation to critical water quality conditions must be carefully evaluated. Capability of energy usage phase down while still maintaining process viability, both under normal and emergency availability conditions, must be included in the activated sludge design.

2. Specific process selection. The activated sludge process and its several modifications may be employed to accomplish varied degrees of removal of suspended solids and reduction of carbonaceous and/or nitrogenous oxygen demand. Choice of the process most applicable will be influenced by the degree and consistency of treatment required, type of waste to be treated, proposed plant size, anticipated degree of operation and maintenance, and operating and capital costs. All designs shall provide for flexibility in operation. Plants over one (1) mgd (3785 m^3/d) shall be designed to facilitate easy conversion to various operation modes.

3. Winter protection. In severe climates, protection against freezing shall be provided to insure continuity of operation and performance.

(B) Pretreatment. Where primary settling tanks are not used, effective removal or exclusion of grit, debris, excessive oil or grease and comminution or screening of solids shall be accomplished prior to the activated sludge process. Where primary settling is used, provision shall be made for discharging raw sewage directly to the aeration tanks to facilitate plant start-up and operation during the initial stages of the plant's design life.

(C) Aeration.

1. Capacities and permissible loadings. The size of the aeration tank for any particular adaptation of the process shall be determined by full scale experience, plant pilot studies or rational calculations based mainly on food to microorganism ratio and mixed liquor suspended solids levels. Other factors such as size of treatment plant, diurnal load variations and degree of treatment required shall also be considered. In addition, temperature, pH and reactor dissolved oxygen shall be considered when designing for nitrification. Calculations should be submitted to justify the basis for design of aeration tank capacity. Calculations using values differing substantially from those in the accompanying table should reference actual operational plants. Mixed liquor suspended solids levels greater than five thousand (5000) mg/l may be allowed provided that adequate data is submitted that shows the aeration and clarification system is capable of supporting the levels. When process design calculations are not submitted, the aeration tank capacities and permissible loadings for the several adaptations of the processes shown in the following table shall be used. These values apply to plants receiving peak to average diurnal load ratios ranging from about two to one (2:1) to four to one (4:1). The utilization of flow equalization facilities to reduce the diurnal peak organic load may be considered by the

agency as justification to approve organic loading rates that exceed those specified in the table.

Permissible Aeration Tank Capacities and Loadings

(NOTE: For proper use of this table, see paragraph (4)(C)1. of this rule.)

Process	Aeration Tank Organic Loading-lb. BOD_5/1,000 cu. ft./day	F/M Ratio-lb. BOD_5/lb. MLVSS/ day	MLSS* mg/liter
Step Aeration, Complete Mix, and Conventional	40	0.2–0.5	1000–3000
Contact Stabilization	50**	0.2–0.6	1000–3000
Extended Aeration and Oxidation-Ditches	15	0.05–0.1	3000–5000

*MLSS values are dependent upon the surface area provided for sedimentation and the rate of sludge return as well as the aeration process.

**Total aeration capacity, includes both contact and reaeration capacities. Normally the contact zone equals thirty to thirty-five percent (30%–35%) of the total aeration capacity.

2. Arrangement of aeration tanks.

A. General tank configuration.

(I) Dimensions. The dimensions of each independent mixed liquor aeration tank or return sludge reaeration tank shall be so as to maintain effective mixing and utilization of air. Ordinarily, liquid depths should not be less than ten feet (10') (3 m) or more than thirty feet (30') (9 m) except in special design cases.

(II) Short-circuiting. For very small tanks or tanks with special configuration, the shape of the tank and the installation of aeration equipment should provide the positive control of short-circuiting through the tank.

B. Number of units. Total aeration tank volume required shall be divided among two (2) or more units, capable of independent operation, when required by the agency to meet applicable effluent limitations and reliability guidelines.

C. Inlets and outlets.

(I) Controls. Inlets and outlets for each aeration tank unit shall be suitably equipped with valves, gates, stop plates, weirs or other devices to permit controlling the flow to any unit and to maintain reasonably constant liquid level. The hydraulic properties of the system shall permit the maximum instantaneous hydraulic load to be carried with any single aeration tank unit out-of-service.

(II) Conduits. Channels and pipes carrying liquids with solids in suspension shall be designed to maintain self-cleansing velocities or shall be agitated to keep the solids in suspension at all rates of flow within the design limits. Adequate provisions should be made to drain segments of channels which are not being used due to alternate flow patterns.

D. Freeboard. All aeration tanks should have a freeboard of not less than eighteen inches (18") (46 cm). Additional freeboard or windbreak may be necessary to protect against freezing or wind blown spray.

3. Aeration equipment.

A. General. Oxygen requirements generally depend on maximum diurnal organic loading, degree of treatment and level of suspended solids concentration to be maintained in the aeration tank mixed liquor. Aeration equipment shall be capable of maintaining a minimum of two (2.0) mg/l of dissolved oxygen in the mixed liquor at all times and providing thorough mixing of the mixed liquor. In the absence of experimentally determined values, the design oxygen requirements for all activated sludge processes shall be 1.1 lbs. 0_2/lb. peak BOD_5 applied to the aeration tanks (1.1 kg 0_2/kg peak BOD_5) except the value of 1.8 shall be used for the extended aeration process. In the case of nitrification, the oxygen requirement for oxidizing ammonia must be added to the above requirement for carbonaceous BOD_5 removal. The nitrogen oxygen demand (NOD) shall be taken as 4.6 times the diurnal peak total kjeldahl nitrogen (TKN) content of the influent. In addition, the oxygen demands due to recycle flows—heat treatment supernatant, vacuum filtrate, elutriates, etc., must be considered due to the high concentration of BOD_5 and TKN associated with the flows. Careful consideration should be given to maximizing oxygen utilization per unit power input. Unless flow equalization is provided, the aeration system should be designed to match the diurnal organic load variation while economizing on power input.

B. Diffused air systems. The desire of the diffused air system to provide the oxygen requirements shall be done by either of the following two (2) methods.

(I) Having determined the oxygen requirements per subparagraph (4)(C)3.A. of this rule, air requirements for a diffused air system shall by use of any of the well known equations incorporate such factors as tank depth, alpha factor of waste, beta factor of waste, certified aeration device transfer efficiency, minimum aeration tank dissolved oxygen concentrations, critical wastewater temperature and altitude of plant. In the absence of experimentally determined alpha and beta factors, wastewater transfer efficiency shall be assumed to be fifty percent (50%) of clean water efficiency for plants treating primarily ninety percent (90%) or greater domestic sewage. Treatment plants where the waste contains higher percentages of industrial wastes shall use a correspondingly lower percentage of clean water efficiency and shall have calculations submitted to justify such a percentage.

(II) Normal air requirements for all activated sludge processes except extended aeration (assuming equipment capable of transmitting to the mixed liquor the amount of oxygen required in subparagraph (4)(C)3.A.) shall be considered to be fifteen hundred (1500) cu.ft. per pound of BOD_5 peak aeration tank loading (93.5 m^3/kg of BOD_5). For the extended-aeration process the value shall be two thousand (2000) cu. ft. (125 m).

(III) To the air requirements calculated in part (4)(C)3.B.(II) of this rule shall be added air required for channels, pumps, aerobic digesters or other air-use demand.

(IV) The specified capacity of blowers or air compressors, particularly centrifugal blowers, should take into account that the air intake temperature may reach forty degrees Celsius (40 °C) (one hundred four degrees Fahrenheit (104 °F)) or higher and the pressure may be less than normal. The specified capacity of the motor drive should also take into account that the intake air may be minus thirty degrees Celsius (-30 °C) (minus twenty-two degrees Fahrenheit (-22 °F)) or less and may require oversizing of the motor or a means of reducing the rate of air delivery to prevent overheating or damage to the motor.

(V) The blowers shall be so provided in multiple units, so arranged and in such capacities as to meet the maximum air demand with the single largest unit out-of-service. The design shall also provide for varying the volume of air delivered in proportion to the load demand of the plant. Aeration equipment shall be easily adjustable in increments and shall maintain solids suspension within these limits.

(VI) Diffuser systems shall be capable of providing for the diurnal peak oxygen demand or two hundred percent (200%) of the design average oxygen demand whichever is larger. The air diffusion piping and diffuser system shall be capable of delivering normal

Schedule JAM-5

air requirements with minimal friction losses. Air piping systems should be designed such that total head loss from blower outlet (or silencer outlet where used) to the diffuser inlet does not exceed 0.5 pounds per square inch (psi) (0.04 kgf/cm^2) at average operating conditions. The spacing of diffusers should be in accordance with the oxygen requirements within the channel or tank, and should be designed to facilitate adjustment of their spacing without major revision to air header piping. All plants employing less than four (4) independent aeration tanks shall be designed to incorporate removable diffusers that can be serviced and/or replaced without de-watering the tank.

(VII) Individual assembly units of diffusers shall be equipped with control valves, preferably with indicator markings for throttling or for complete shutoff. Diffusers in any single assembly shall have substantially uniform pressure loss.

(VIII) Air filters shall be provided in numbers, arrangements and capacities to furnish at all times an air supply sufficiently free from dust to prevent damage to blowers and clogging of the diffuser system used.

C. Mechanical aeration systems.

(I) Oxygen transfer performance. The mechanism and drive unit shall be designed for the expected conditions in the aeration tank in terms of the power performance. Certified testing shall verify mechanical aerator performance.

(II) Design requirements. The design requirements of a mechanical aeration system shall accomplish the following: maintain a minimum of two (2.0) mg/l of dissolved oxygen in the mixed liquor at all times throughout the tank or basin; maintain all biological solids in suspension; meet maximum oxygen demand and maintain process performance with the largest unit out-of-service; and provide for varying the amount of oxygen transferred in proportion to the load demand on the plant.

(III) Winter protection. Due to high heat loss, the mechanism as well as subsequent treatment units shall be protected from freezing where extended cold weather conditions occur.

(D) Return Sludge Equipment.

1. Return sludge rate. The minimum permissible return sludge rate of withdrawal from the final settling tank is a function of the concentration of suspended solids in the mixed liquor entering it, the sludge volume index of these solids and the length of time these solids are retained in the settling tank. Since undue retention of solids in the final settling tanks may be deleterious to both the aeration and sedimentation phases of the activated sludge process, the rate of sludge return expressed as a percentage of the average design flow of sewage should generally be variable between the limits set forth as follows:

	Minimum	Maximum
Standard Rate	15	75
Carbonaceous Stage of Separate Stage Nitrification	15	75
Step Aeration	15	75
Contact Stabilization	50	150
Extended Aeration	50	150
Nitrification Stage of Separate Stage Nitrification	50	200

The rate of sludge return shall be varied by means of variable speed motors, drives or times (small plants) to pump sludge at the rates mentioned in the previous table.

2. Return sludge pumps. If motor driven return sludge pumps are used, the maximum return sludge capacity shall be obtained with the largest pump out-of-service. A positive head should be provided on pump suctions. Pumps should have at least three-inch (3") (7.6 cm) suction and discharge openings. If air lifts are used for returning sludge from each settling tank hopper, no standby unit will be required provided the design of the air lifts are so as to facilitate their rapid and easy cleaning and provided other suitable standby measures are provided. Air lifts should be at least three inches (3") (7.6 cm) in diameter.

3. Return sludge piping. Discharge piping should be at least four inches (4") (10 cm) in diameter and should be designed to maintain a velocity of not less than two feet (2') per second (0.61 m/s) when return sludge facilities are operating at normal return sludge rates. Suitable devices for observing, sampling and controlling return activated sludge flow from each settling tank hopper shall be provided.

4. Waste sludge facilities. Waste sludge control facilities should have a maximum capacity of not less than twenty-five percent (25%) of the average rate of sewage flow and function satisfactorily at rates of 0.5 percent of average sewage flow or a minimum of ten (10) gallons per minute (0.63 l/s), whichever may be the larger. Means for observing, measuring, sampling and controlling waste activated sludge flow shall be provided. Waste sludge may be discharged to the concentration or thickening tank, primary settling tank, sludge digestion tank, vacuum filters or any practical combination of these units.

(E) Measuring Devices. Devices should be installed in all plants for indicating flow rates of raw sewage or primary effluent, return sludge and air to each tank unit. For plants designed for sewage flows of 1 mgd (3785 m^3/d) or more, these devices should totalize and record, as well as, indicate flows. Where the design provides for all return sludge to be mixed with the raw sewage (or primary effluent) at one (1) location, then the mixed liquor flow rate to each aeration unit should be measured.

(5) Rotating Biological Contactors.

(A) General.

1. Applicability. The rotating biological contactor (RBC) process may be used where sewage is amenable to biological treatment. The process may be used to accomplish carbonaceous and/or nitrogenous oxygen demand reductions. Design standards, operating data and experience for this process are not well established. Therefore, expected performance of RBCs shall be based upon experience to similar full scale installations or thoroughly documented pilot testing with the particular wastewater.

2. Winter protection. Wastewater temperature affects rotating contactor performance. Year round operation in colder climates requires that rotating contactors be covered to protect the biological growth from cold temperatures and the excessive loss of heat from the wastewater with the resulting loss of performance. Enclosures shall be constructed of a suitable corrosion-resistant material. Windows or simple louvered mechanisms which can be opened in the summer and closed in the winter shall be installed to provide adequate ventilation. To minimize condensation, the enclosure should be adequately insulated and/or heated.

(B) Required Pretreatment. RBCs must be preceded by effective settling tanks equipped with scum and grease collecting devices unless substantial justification is submitted for other pretreatment devices which provide for effective removal of grit, debris and excessive oil or grease prior to the RBC units. Bar screening or comminution are not suitable as the sole means of pretreatment.

(C) Unit Sizing. Unit sizing shall be based on experience at similar full-scale installations or thoroughly documented pilot testing with the particular wastewater. In determining design loading rates, expressed in units of volume per day per unit area of media covered by biological growth, the following parameters must be considered: design flow rate and influent waste strength; percentage of BOD_5 to be removed; media arrangement including number of stages and unit area in each stage; rotational velocity of the media; retention time within the tank containing the media; and wastewater temperature; and the percentage of influent BOD_5 which is soluble. In addition to these parameters, loading rates for nitrification will depend upon influent TKN, pH and the allowable effluent ammonia nitrogen concentration.

(D) Design Safety Factor. Effluent concentrations of ammonia nitrogen from the RBC process designed for nitrification are affected by diurnal load variations. Therefore, it may be necessary to increase the design surface area proportional to the ammonia nitrogen diurnal peaking rates appropriately to meet effluent limitations. An alternative is to provide flow equalization sufficient to insure process performance within the required effluent limitations.

(6) Other Biological Systems. New biological treatment schemes with promising applicability in wastewater treatment may be considered if the required engineering data for new process evaluation is provided in accordance with 10 CSR 20-8.140(5)(B).

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.190 Disinfection

PURPOSE: The following criteria have been prepared as a guide for the design of disinfection facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred gallons per day (22,500 gpd) (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Forms of Disinfection. Chlorine is the most commonly used chemical for wastewater disinfection. The forms most often used are liquid chlorine and calcium or sodium hypochlorite. Other disinfectants, including chlorine dioxide, ozone or bromine, may be accepted by the agency in individual cases. The chemical should be selected after due consideration of waste flow rates, application and demand rates, pH of the wastewater, cost of equipment, chemical availability and maintenance problems. If chlorination is utilized, it may be necessary to dechlorinate if the chlorine level in the effluent would impair the natural aquatic habitat of the receiving stream.

(4) Feed Equipment.

(A) Type. Solution-feed vacuum-type chlorinators are generally preferred for large chlorination installations. The use of hypochlorite feeders of the positive displacement type may be considered and are generally preferred when intermittent disinfection is required. The preferred method of generation of chlorine dioxide is the injection of a sodium chlorite solution into the discharge line of a solution-feed gas-type chlorinator with subsequent formation of the chlorine dioxide in a reaction chamber at a pH of four (4.0) or less. Ozone dissolution is accomplished through the use of conventional gas diffusion equipment, with appropriate consideration of materials. If ozone is being produced from air, gas preparation equipment (driers, filters, compressors) is required. If ozone is being produced from oxygen, this equipment may not be needed as a clean dry pressurized gas supply will be available.

(B) Control.

1. Chlorination without dechlorination. Facilities with design flows of one million gallons per day (1.0 mgd) (3785 m^3/d) or greater shall be equipped with a chlorine rate control to feed the chlorine proportional to the flow of wastewater and the chlorine residual. Facilities with design flows between one (1.0) mgd (3785 m^3/d) and twenty-two thousand five hundred (22,500) gpd (85.4 m^3) should be equipped with a control system to feed the chlorine proportional to the flow of wastewater.

2. Chlorination with dechlorination. All facilities designed for dechlorination must be equipped to feed the chlorine proportional to the flow of wastewater and the chlorine residual. Dechlorination equipment shall be equipped to feed in proportion to the flow of wastewater.

3. Ozone. Facilities for disinfection with ozone should be equipped to feed the ozone in proportion to the flow of wastewater.

(C) Capacity. Required disinfection capacity will vary, depending on the uses and points of application of the disinfecting chemical. For disinfection, the capacity should be adequate to produce an effluent that will meet the coliform limits specified by the agency. For normal domestic sewage, the following may be used as a guide in sizing chlorination facilities.

Type of Treatment	Dosage
Trickling filter plant	10 mg/l
Activated sludge plant effluent	8 mg/l
Tertiary filtration effluent	6 mg/l
Nitrified effluent	6 mg/l

(D) Standby Equipment and Spare Parts. Standby equipment of sufficient capacity should be available to replace the largest unit during shutdowns. Spare parts shall be available for all disinfection equipment to replace parts which are subject to wear and breakage.

Schedule JAM-5

(E) Water Supply. An ample supply of water shall be available for operating the chlorinator. Where a booster pump is required, duplicate equipment should be provided and when necessary, standby power as well. Protection of a potable water supply shall conform to the requirements of 10 CSR 20-8.140(8)(B).

(5) Chlorine Supply.

(A) General. The type of chlorine supply should be carefully evaluated during the planning process. Large quantities of chlorine are contained in ton cylinders and tank cars can present a considerable hazard to plant personnel and to the surrounding area should the containers develop leaks.

(B) Containers. The use of ton containers should be considered where the average daily chlorine consumption is over one hundred fifty pounds (150 lbs.) (68 kg). Both monetary cost and the potential residential exposure to chlorine should be considered when making the final determination.

(C) Tank Cars. At large chlorination installations consideration should be given to the use of tank cars, generally accompanied by gas evaporators. Both monetary cost and the potential residential exposure to chlorine should be considered when making the final determination. Liquid chlorine lines from tank cars to evaporators shall be buried and installed in a conduit and shall not enter below grade spaces. Systems shall be designed for the shortest possible pipe transportation of liquid chlorine.

(D) Scales. Scales for weighing cylinders shall be provided at all plants using chlorine gas. At large plants, scales of the indicating and recording type are recommended. At least a platform scale shall be provided. Scales shall be of corrosion-resistant material.

(E) Evaporators. Where manifolding of several cylinders or ton containers will be required to evaporate sufficient chlorine, consideration should be given to the installation of evaporators, to produce the quantity of gas required.

(F) Leak Detection and Controls. A bottle of fifty-six percent (56%) ammonium hydroxide solution shall be available for detecting chlorine leaks. Where ton containers or tankcars are used, a leak repair kit approved by the Chlorine Institute shall be provided. Consideration should be given to the provision of caustic soda solution reaction tanks for absorbing the contents of leaking ton containers where the containers are in use. At large chlorination installations, consideration should be given to the installation of automatic gas detection and related alarm equipment. For ozone installations, similar purpose equipment shall be provided.

(6) Ozone Generation. Ozone may be produced from either an air or an oxygen gas source. Generation units shall be automatically controlled to adjust ozone production to meet disinfection requirements.

(7) Piping and Connections. Piping systems should be as simple as possible, specifically selected and manufactured to be suitable for chlorine or ozone service, with a minimum number of joints. Piping should be well supported and protected against temperature extremes. The correct weight or thickness of steel is suitable for use with dry chlorine liquid or gas. Even minute traces of water added to chlorine results in a corrosive attack that can only be resisted by pressure piping utilizing materials such as silver, gold, platinum or Hasteloy C. Low pressure lines made of hard rubber, saran-lined, rubber-lined, polyethylene, polyvinylchloride (PVC) or Uscolite materials are satisfactory for wet chlorine or aqueous solutions of chlorine. Due to the corrosiveness of wet chlorine, all lines designed to handle dry chlorine should be protected from the entrance of water or air containing water. For ozonation systems, the selection of material should be made with due consideration for ozone's corrosive nature. Copper or aluminum alloy should be avoided. Stainless steel with a corrosion resistance of at least equal to grade 304 L should be specified for piping containing ozone in nonsubmerged applications. Unplasticized PVC, Type 1, may be used in submerged piping, provided the gas temperature is below one hundred forty degrees Fahrenheit (140 °F) (60 °C) and the gas pressure is low.

(8) Housing.

(A) Separation. If gas chlorination equipment, chlorine cylinders or ozone generation equipment are to be in a building used for other purposes, a gas-tight room shall separate this equipment from any other portion of the building. Floor drains from the chlorine room should not be connected to floor drains from other rooms. Doors to this room shall open only to the outside of the building and shall be equipped with panic hardware. The rooms shall be at ground level and should permit easy access to all equipment. Storage area should be separate from the feed area. Chlorination equipment should be situated as close to the application point as reasonably possible.

(B) Inspection Window. A clear glass, gas-tight window shall be installed in an exterior door or interior wall of the chlorinator or ozone generator room to permit the units to be viewed without entering the room.

(C) Heat. Rooms containing disinfection equipment shall be provided with a means of heating so that a temperature of at least sixty degrees Fahrenheit (60 °F) (16 °C) can be maintained but the room should be protected from excess heat. Cylinders shall be kept at essentially room temperature. The room containing the ozone generation units shall be maintained above thirty-five degrees Fahrenheit (35 °F) (2 °C) at all times.

(D) Ventilation. With chlorination systems, forced, mechanical ventilation shall be installed which will provide one (1) complete air change per minute when the room is occupied. For ozonation systems, continuous ventilation to provide at least six (6) complete air changes per hour should be installed. The entrance to the air exhaust duct from the room shall be near the floor and the point of discharge shall be so located as not to contaminate the air inlet to any buildings or inhabited areas. Air inlets shall be so located as to provide cross ventilation with air and at a temperature that will not adversely affect the chlorination of ozone generation equipment. The vent hose from the chlorinator shall discharge to the outside atmosphere above grade.

(E) Electrical Controls. Switches for fans and lights shall be outside of the room at the entrance. A labeled signal light indicating fan operation should be provided at each entrance, if the fan can be controlled from more than more one (1) point.

(9) Respiratory Protection. Respiratory air-pac protection equipment, meeting the requirements of the National Institute for Occupational Safety and Health (NIOSH) shall be available where chlorine gas is handled and shall be stored at a convenient location but not inside any room where chlorine is used or stored. Instructions for using, testing and replacing mask parts including canisters, shall be posted adjacent to the equipment. The units shall use compressed air, have at least thirty (30)-minute capacity and be compatible with the units used by the fire department responsible for the plant.

(10) Application of Chlorine or Ozone.

(A) Mixing. The disinfectant shall be positively mixed as rapidly as possible, with a complete mix being effected in three (3) seconds. This may be accomplished by either the use of turbulent flow regime or a mechanical flash mixer.

(B) Contact Period. For a chlorination system, a minimum contact period of fifteen (15) minutes at peak hourly flow or maximum rate of pumpage shall be provided after thorough mixing. Consideration should be given to running a field tracer study to assure adequate contact time. If dechlorination is required after complete mixing of the effluent with the chemical, no further contact time is necessary. The required contact time for an ozonation unit varies with the type of dissolution equipment used. Certain high rate devices require contact times less than one (1) minute to achieve disinfection while conventional dissolution equipment may require contact times similar to chlorination systems.

(C) Contact Tank. The chlorine or ozone contact tank shall be constructed so as to reduce short-circuiting of flow to a practical minimum. Baffles shall be parallel to the longitudinal axis of the chamber with a minimum length to width ratio of forty to one (40:1) (the total length of the channel created by the baffles should be forty (40) times the distance between the baffles). The tank should be designed to facilitate maintenance and cleaning without reducing effectiveness of disinfection. Duplicate tanks, mechanical scrapers or portable deck level vacuum cleaning equipment shall be provided. Consideration should be given to providing skimming devices on all contact tanks. Covered tanks are discouraged.

(11) Evaluation of Effectiveness.

(A) Sampling. Facilities shall be included for sampling the disinfected effluent after contact. In large installations, or where stream conditions warrant, provisions should be made for continuous monitoring of effluent chlorine residual.

(B) Testing. Equipment shall be provided for measuring chlorine residuals using accepted test procedures. Automatic equipment required by subsection (4)(C) of this rule may be used to meet the requirements of this subsection. Equipment shall also be required for measuring fecal coliform using accepted test procedures as required by 10 CSR 20-9.010.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.200 Wastewater Treatment Ponds (Lagoons)

PURPOSE: The following criteria have been prepared as a guide for the design of wastewater treatment ponds (lagoons). This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

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(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) General. This rule deals with generally used variations of treatment ponds to achieve secondary treatment including controlled discharge pond systems, flow-through pond systems and aerate pond systems. Ponds utilized for equalization, percolation, evaporation and sludge storage will not be discussed in this rule.

(4) Supplement to Engineer's Report. The engineer's report shall contain pertinent information on location, geology, soil conditions, area for expansion and any other factors that will affect the feasibility and acceptability of the proposed project. The following information must be submitted in addition to that required in 10 CSR 20-8.110.

(A) Supplementary Field Survey Data.

1. The location and direction of all residences, commercial developments, parks, recreational areas and water supplies, including a log of each well if available within one-half (1/2) mile (0.8 km) of the proposed pond shall be included in the engineer's report.

2. Land use zoning adjacent to the proposed pond site shall be included.

3. A description, including maps showing elevations and contours, of the site and adjacent area shall be provided. Due consideration shall be given to additional treatment units and/or increased waste loadings in determining land requirements. Current United States Geological Survey and Soil Conservation Service maps may be considered adequate for preliminary evaluation of the proposed site.

4. The location, depth and discharge point(s) of any field tile in the immediate area of the proposed site shall be identified.

5. A geological evaluation of the proposed lagoon site prepared by the Division of Geology and Land Survey (DGLS) shall be submitted. To obtain this geological evaluation of the proposed site, the engineer shall submit the following information to the Department of Natural Resources, Division of Geology and Land Survey, P.O. Box 250, Rolla, MO 65401:

A. A layout sheet showing the proposed location. The layout shall include the legal description, property boundaries, roads, streams and other geographical landmarks which will assist in locating the site;

B. Size of the lagoon and/or approximate volume of waste to be treated;

C. Maximum cuts to be made in the construction of the lagoon; and

D. Location and depth of cut for borrow area, if any.

6. Sulfate content of the primary water supply shall be determined.

7. Data from all soil borings conducted by a professional soil testing laboratory to determine subsurface soil characteristics and groundwater characteristics, including elevation, at the proposed site and their effect on the construction and operation of a pond shall also be provided. All boring holes shall be filled and sealed. The permeability characteristics of the pond bottom and pond seal material shall also be studied. At the facility plan

Schedule JAM-5

stage particle size analysis, Atterburg limits, standard Procter density (moisture-density relations) or permeability coefficient may be required on a case-by-case basis to reflect soil characteristics. At the twenty percent (20%) design stage, soil analysis of each representative soil material including particle size analysis, Atterburg limits, standard Procter density (moisture-density relations) and permeability coefficient of the compacted soil as measured in a falling head permeameter or other test procedure acceptable to the agency may be required. Soil borings may be required in each geological area to determine depth to piezometric surface and to bedrock. Recommendations of the DGLS will be used to establish the required tests at the facility plan and twenty percent (20%) design stages.

(B) Site Information.

1. Distance from habitation. Lagoon sites should be as far as practicable from habitation or any area which may be built up within a reasonable future period. The agency does not attempt to set any minimum distance from habitation since each case must be judged upon its own merits.

2. Prevailing winds. If practicable, ponds should be located so that local prevailing winds will be in the direction of uninhabited areas.

3. Surface runoff. Location of ponds in watersheds receiving significant amounts of stormwater runoff is discouraged. Adequate provisions must be made to divert stormwater runoff around the ponds and protect embankments from erosion.

4. Hydrology. Construction of ponds in close proximity to water supplies and other facilities subject to contamination should be avoided. A minimum separation of four feet (4') (1.2 m) between the bottom of the pond and the maximum groundwater elevation should be maintained where feasible.

5. Groundwater pollution. Proximity of lagoons to water supply located in areas of porous soils and fissured rock formation shall be elevated to avoid creation of health hazards or other undesirable conditions. If the geological report from DGLS makes suggestions for remedial treatment of the site, the engineer shall comply with the suggestions. In some cases, the engineering geologist requests to visit the site during or after construction. When a request is made, the consulting engineer shall comply with the request.

(5) Basis of Design.

(A) Quality of Effluent. A controlled discharge stabilization pond (four (4)-cell) will be considered capable of meeting effluent limitations of thirty (30) mg/l biochemical oxygen demand (BOD_5) and thirty (30) mg/l suspended solids. Flow-through stabilization ponds (three (3)-cell), and aerated lagoon systems will be considered capable of meeting effluent limitations of thirty (30) mg/l BOD_5 and eighty (80) mg/l suspended solids. Flow-through lagoon systems and aerated lagoon systems followed by submerged sand filters will be considered capable of meeting effluent limitations of twenty (20) mg/l BOD_5 and twenty (20) mg/l suspended solids. Lagoons may be incorporated into irrigation systems or systems utilizing chemical coagulation and filtration to meet the requirements of 10 CSR 20-7.015(3)(A)3. Please refer to 10 CSR 20-7.015 Effluent Regulation for discharge requirements.

(B) Area and Loadings for Controlled Discharge Stabilization Ponds (four (4)-cell). Pond design for BOD_5 loadings shall not exceed thirty-four (34) lbs./acre/day (38 km per hectare per day) at the three-foot (3') (1.9 m) operating depth in the primary cells. The primary cell shall be followed by a secondary cell having 0.3 the area of the primary cell and by two (2) storage cells. The two (2) storage cells shall have a volume above the two-foot (2') (0.6 m) level for one (1) month's storage of average daily flow in each cell. At least one hundred twenty (120) days' detention time between the two-foot (2') level (0.6 m) and the maximum operating depth shall be provided in the entire pond system. Flow can be based on one hundred (100) gallons per capita per day (38 m^3/cap/d) or other values if data is presented to justify the rate. Primary and secondary cells shall be designed for water depths up to a maximum of five feet (5') (1.5 m). The storage cell should be made as deep as possible up to a maximum depth of eight feet (8') (2.4 m).

(C) Area and Loadings for Flow-through Stabilization Ponds (three (3)-cell). Pond design for BOD_5 loadings shall not exceed thirty-four (34) pounds per acre per day (38 km per hectare per day). The second cell must be at least 0.3 the area of the first cell and the third cell 0.1 the area of the first cell. The first and second cells must have a variable operating level of between two feet (2') (0.6 m) and five feet (5') (1.5 m). The third cell must have a variable operating level of between two feet (2') (0.6 m) and eight feet (8') (2.4 m). Detention time of at least one hundred twenty (120) days must be provided. Flows of less than one hundred (100) gallons per capita per day (.38 m^3/cap/d) may be used if data is presented to justify the lower rate.

(D) Aerated Lagoons. For the development of final design parameters it is recommended that actual experimental data be developed; however, the aerated lagoon design for minimum detention time may be estimated using the following formula:

$$t = \frac{E}{2.3\ K_1 \times (100-E)}$$

where:

t = detention time in the aeration cell in days;

E = percent of BOD_5 to be removed in an aerated pond; and

K_1 = reaction coefficient aerated lagoon, base 10.

For normal domestic sewage the K_1 value may be assumed to be .15 per day for Missouri conditions. The reaction rate coefficient for domestic sewage which includes some industrial waste, other waste or partially treated sewage must be determined experimentally for various conditions which might be encountered in the aerated ponds. Conversion of the reaction coefficient at other temperatures shall be based on experimental data. Raw sewage strength should also consider the effect of any return sludges. Also, additional storage volume should be considered for sludge and in northern climates, ice cover. Oxygen requirements generally will depend on the BOD_5 loading, the degree of treatment and the concentration of suspended solids to be maintained. Aeration equipment shall be capable of maintaining a minimum dissolved oxygen level of two (2) mg/l in the ponds at all times. Suitable protection from weather shall be provided for electrical controls. The aeration equipment shall be capable of providing 1.3 pounds of oxygen per pound of BOD_5 (1.3 kg/kg BOD_5) removed. BOD_5 removal shall be based on warm weather rates. Aerated cells shall be followed by a polishing cell with a volume of 0.3 of the volume of the aerated cell (see 10 CSR 20-8.180 for details on aeration equipment).

(E) Multiple Units. Parallel cells should be considered for large installations. The maximum size of any cell should be forty (40) acres (16 ha). The system should be designed to permit isolation of any cell without disrupting service of the other cells.

(F) Pond Shape. The shape of all cells should be so that there are no narrow or elongated portions. Round, square or rectangular ponds with a length not exceeding three (3) times the width are considered most desirable. No islands, peninsulas or coves shall be permitted. Dikes should be rounded at corners to minimize accumulation of floating materials. Common dike construction, wherever possible, is strongly encouraged.

(G) Industrial Wastes. Consideration shall

Schedule JAM-5

be given to the type and effects of industrial wastes on the treatment process. In some cases it may be necessary to pretreat industrial or other discharges. Industrial wastes shall not be discharged to ponds without assessment of the effects the substances may have upon the treatment processor discharge requirements in accordance with state and federal laws.

(H) Additional Treatment. Consideration should be given in the design stage to the utilization of additional treatment units as may be necessary to meet applicable discharge standards (see paragraph (4)(A)3. of this rule).

(6) Pond Construction Details.

(A) Embankments and Dikes.

1. Material. Dikes shall be constructed of relatively impervious material and compacted to at least ninety-five percent (95%) standard Procter density to form a stable structure. Vegetation and other unsuitable materials shall be removed from the area where the embankment is to be placed.

2. Top width. The minimum dike width shall be eight feet (8') (2.4 m) to permit access of maintenance vehicles.

3. Maximum slopes. Inner and outer dike slopes shall not be steeper than three horizontal to one vertical (3:1).

4. Minimum slopes. Inner slopes should not be flatter than four horizontal to one vertical (4:1). Flatter slopes can be specified for larger installations because of wave action but have the disadvantage of added shallow areas being conducive to emergent vegetation. Outer slopes shall be sufficient to prevent surface runoff from entering the ponds.

5. Freeboard. Minimum freeboard shall be two feet (2') (0.6 m). For very large cells, three feet (3') (1.0 m) should be considered.

6. Design depth. The minimum operating depth should be sufficient to prevent growth of aquatic plants and damage to the dikes, bottom, control structures, aeration equipment and other appurtenances. In no case should pond depths be less than two feet (2') (0.6 m). The design water depth for aerated lagoons should be ten to fifteen feet (10–15') (3–4.5 m). This depth limitation may be altered depending on the aeration equipment, waste strength, climatic conditions and geologic conditions.

7. Erosion control. A justification and detailed discussion of the method of erosion control which encompasses all relative factors such as pond location and size, variations in operating depths, seal material, topography, prevailing winds, cost breakdown, application procedures, etc., shall be provided.

A. Seeding. The dikes shall have a cover layer of fertile topsoil with a minimum thickness of four inches (4") (10 cm) to promote establishment of an adequate vegetative cover wherever riprap is not utilized. Prior to prefilling (in accordance with paragraph (6)(C)3. of this rule), adequate vegetation shall be established on dikes from the outside toe to one foot (1') above the water line measured on the slope. Perennial-type, low growing, spreading grasses that minimize erosion and can be mowed are most satisfactory for seeding of dikes. In general, alfalfa and other long-rooted crops should not be used for seeding since the roots of this type are apt to impair the water holding efficiency of the dikes. Alternate dike stabilization practices may be considered if vegetative cover cannot be established prior to prefilling.

B. Additional erosion protection. Riprap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s) design should ensure erosion protection on the slopes and bottoms in the areas where turbulence will occur. Additional erosion control may also be necessary on the exterior dike slope(s) to protect the embankment(s) from erosion due to severe flooding of a water course.

C. Alternate erosion protection. Alternate erosion control on the interior dike slopes may be necessary for ponds which are subject to severe wave action. In these cases riprap or an acceptable equal shall be placed from one foot (1') (.3 m) above the high water mark to two feet (2') (0.6 m) below the low water mark (measured on the vertical). This protection should also be provided in the storage cells of a controlled discharge (four (4)-cell) pond and the third cell of a flow-through pond (three (3)-cell) where large fluctuations in operating depths will occur.

(B) Pond Bottom.

1. Soil. Soil used in constructing the pond bottom (not including the seal) and dike cores shall be selected to avoid settlement. Soil shall be compacted with the moisture content between two percent (2%) below and four percent (4%) above the optimum water content and to the specified standard Procter density but no less than ninety-five percent (95%) standard Procter density.

(C) Seal.

1. Design. Ponds shall be sealed so that seepage loss through the seal is as low as practicably possible. Seals consisting of soils or synthetic liners may be used provided the permeability, durability, integrity and cost effectiveness of the proposed materials can be satisfactorily demonstrated for anticipated conditions. Bentonite, soda ash or other sealing aids may be used to achieve an adequate seal in systems using soil. Results of a testing program which substantiates the adequacy of the proposed seal must be incorporated into and/or accompany the engineering report. Standard ASTM procedures or other acceptable methods shall be used for all tests. Soils having a permeability coefficient of 10-cm/sec or less with a compacted thickness of twelve inches (12") (30.5 cm) will be acceptable as a lagoon seal for water depths up to five feet (5') (1.5 m). For permeability coefficients greater than $10^{-7\ cm/sec}$ or for heads over five feet (5') (1.5 m) such as an aerated lagoon system, the following formula shall be used to determine minimum seal thickness:

$$t = \frac{H \times K}{5.4 \times 10^{-7\ \text{cm/sec}}}$$

where:

K = the permeability coefficient of the soil in question;

H = the head of water in the lagoon; and

t = the thickness of the soil seal.

Units for H and t may be English or metric; however, they must be the same. For a seal consisting of an artificial liner, seepage loss shall not exceed the equivalent of the rate expressed in this paragraph.

2. Normal construction methods will include over-excavation below grade level of twelve inches (12") (30.5 cm), scarification and compaction of base material to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum, and compaction of lifts generally not exceeding six inches (6") (15.2 cm) to ninety-five percent (95%) standard Procter density at moisture content between two percent (2%) below and four percent (4%) above optimum. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift. The cut face of dikes must also be over-excavated and compacted in lifts not to exceed six inches (6") (15.2 cm) per lift. Soils containing plastic clay may be excluded from this construction requirement on a case-by-case basis based on particle size analysis and Atterburg limits. In fact, with some clay soils, satisfactory construction cannot be obtained by over-excavation and recompaction. Construction control must include field density. A minimum of two (2) density tests per acre or not less than three (3) tests must be performed for the base and each lift. Permeability tests of field compacted material may be performed at the option of the consulting engineer.

3. Prefilling. The pond shall be prefilled in order to protect the liner, to prevent weed

Schedule JAM-5

growth, to reduce odor, to allow measurement of percolation losses and to maintain moisture content of the seal. However, the dikes must be completely prepared as described in subparagraphs (6)(A)7.A. and/or B. of this rule before the introduction of water. If the lagoon bottom is allowed to dry, the seal must be recompacted as required in paragraph (6)(C)2.

4. Percolation losses. Measurement of percolation losses shall consider flow into and out of the lagoon, rainfall and evaporation, and changes in water level. Measured percolation losses in excess of one-sixteenth inch (1/16") (1.6 mm) per day will be considered excessive.

(D) Influent Lines.

1. Material. Cast- or ductile-iron pipe should be used for the influent line to the pond. Unlined corrugated metal pipe should be avoided due to corrosion problems. Other materials selected shall be suited to local conditions. In material selection, consideration must be given to the quality of the wastes, exceptionally heavy external loadings, abrasion, soft foundations and similar problems.

2. Manhole. A manhole shall be installed prior to entrance of the influent line into the primary cell(s) and shall be located as close to the dike as topography permits. Its invert shall be at least six inches (6") (15 cm) above the maximum operating level of the pond and provide sufficient hydraulic head without surcharging the manhole.

3. Flow distribution. Flow distribution structures shall be designed to effectively split hydraulic and organic loads equally to the primary cells.

4. Influent line(s). The influent line(s) shall be located along the bottom of the pond so that the top of the pipe is just below the average elevation of the pond seal; however, the pipe shall have adequate seal below it.

5. Point of discharge. All primary cells shall have individual influent line(s) which terminate at approximately the center of the cell so as to minimize short-circuiting. Consideration should be given to multi-influent discharge points for primary cells of twenty (20) acres (8 hectares) or larger to enhance distribution of the waste load on the cell. All aerated cells shall have influent lines which distribute the load within the mixing zone of the aeration equipment. Consideration of multi-inlets should be closely evaluated for any diffused aeration systems.

6. Influent discharge apron. The influent line(s) shall discharge horizontally into the shallow saucer-shaped depression. The end of the discharge line(s) shall rest on a suitable concrete apron large enough so that the terminal influent velocity at the end of the apron does not cause soil erosion. A minimum size apron of two feet (2') (0.6 m) square shall be provided.

(E) Control Structures and Interconnecting Piping.

1. Structure. Facilities design shall consider the use of multipurpose control structures, where possible, to facilitate normal operational functions such as drawdown and flow distribution, flow and depth measurement, sampling, pumps for recirculation, chemical additions and mixing and to minimize the number of construction sites within the dikes. As a minimum, control structures shall be accessible for maintenance and adjustment of controls; adequately ventilated for safety and to minimize corrosion; locked to discourage vandalism; contain controls to allow water level and flow rate control, complete shut off and complete draining; constructed of noncorrosive materials (metal on metal contact in controls should be of like alloys to discourage electrochemical reactions); and located to minimize short-circuiting within the cell and avoid freezing and ice damage. Recommended devices to regulate the water level are valves, slide tubes or dual slide gates. Regulators should be designed so that they can be preset to stop flows at any pond elevation.

2. Piping. All piping shall be of cast-iron or other acceptable materials. The piping should not be located within the seal. Seep collars shall be provided on drain pipes where they pass through the pond seal. Backfill around the drain pipe shall be placed and compacted in the same manner as the pond seal. Pipes should be anchored with adequate erosion control.

A. Drawdown structure piping.

(I) Multilevel outlets. The outlet structure on each pond cell, except aerated cells, shall be designed to permit overflow at one-foot (1') (30.5 cm) increments between the two foot (2') (61 cm) level and the maximum operating level. Suitable baffling shall be provided to prevent discharge of scum or other floating materials. Means must be provided to prevent unauthorized variance of the lagoon depth. A flap valve shall be provided at the outlet end of the final cell overflow or drain pipe to prevent entrance of animals or backwater from flooding.

(II) Pond drain. All ponds shall have emergency drawdown piping to allow complete draining for maintenance. These should be incorporated into the previously described structures. Sufficient pumps and appurtenances shall be made available to facilitate draining of individual ponds if ponds cannot be drained by gravity.

(III) Emergency overflow. To prevent overtopping of dikes, emergency overflow should be provided.

B. Hydraulic Capacity. The hydraulic capacity for constant discharge structures and piping shall allow for a minimum of two hundred fifty percent (250%) of the design flow of the system. The hydraulic capacity for controlled discharge systems shall permit transfer of water at a minimum rate of six inches (6") (15.2 cm) of pond water depth per day at the available head.

(7) Submerged Sand Filters.

(A) Applications. Submerged sand filters may be used for solids and BOD_5 removal following waste stabilization ponds and are considered to be both a third lagoon cell and solids removal facility when designed according to the parameters in subsection (7)(B) of this rule.

(B) Design Details.

1. Following nonaerated waste stabilization ponds, the loading shall not exceed five (5) gallons per day per square foot (.2 m^3/m^2/day) of sand. Following aerated waste stabilization ponds, the loading shall not exceed fifteen (15) gallons per day per square foot (.6 m^3/m^2/day) of sand.

2. Clean graded gravel, preferably placed in at least three (3) layers should be placed around the underdrains and to a depth of at least six inches (6") (15 cm) over the top of the underdrains. Suggested gradings for the three (3) layers are: one and one-half inches to three-fourths inch (1 1/2"–3/4") (3.8 cm–1.9 cm), three-fourths inch to one-fourth inch (3/4"–1/4") (1.9 cm–.6 cm) and one-fourth inch to one-eighth inch (1/4"–1/8") (.6 cm–.3 cm).

3. At least twenty-four inches (24") (0.6 m) of clean washed sand should be provided. The sand should have an effective size of 0.3–1.0 mm and a uniformity coefficient of 3.5 or less.

4. Open-joint or perforated pipe underdrains may be used. They should be spaced not to exceed ten-foot (10') (3.0 m) center-to-center.

5. The earth base of the filters should be sloped to the underdrains or the underdrains may simply be placed in the gravel base on the flat bottom of the basin.

6. The depth of liquid above the sand must be adjustable from one to five feet (1–5') (.3 m–1.5 m).

7. At least two (2) cells must be provided with the combined capacity equal to that necessary for the design loading.

8. A vehicle access ramp from the top of the embankment down to the sand surface and running along one (1) side of the filter is

a desirable feature for periodic maintenance of the filter.

(8) Miscellaneous.

(A) Fencing. The pond area shall be enclosed with an adequate fence to discourage trespassing and prevent entering of livestock. Minimum fence height shall be five feet (5') (1.5 m). The fence may be of the chain link or woven type. Fencing shall not obstruct vehicle traffic or mowing operations on the dike. A vehicle access gate of sufficient width to accommodate mowing equipment shall be provided. All access gates shall be provided with locks.

(B) Access. An all-weather access road shall be provided to the pond site to allow year-round maintenance of the facility.

(C) Warning Signs. Appropriate permanent signs shall be provided along the fence around the pond to designate the nature of the facility and advise against trespassing. At least one (1) sign shall be provided on each side of the site and one (1) for every five hundred feet (500') (150 m) of its perimeter.

(D) Flow Measurement. Refer to 10 CSR 20-8.140(8)(G).

(E) Groundwater Monitoring. An approved system of groundwater monitoring wells or lysimeters may be required around the perimeter of the pond site to facilitate groundwater monitoring. The use of wells and/or lysimeters will be determined on a case-by-case basis.

(F) Laboratory Equipment. Refer to 10 CSR 20-8.140(8)(D).

(G) Pond Level Gauges. Pond level gauges shall be provided.

(H) Service Building. Consideration in design should be given to a service building for laboratory and maintenance equipment.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.210 Supplemental Treatment Processes

PURPOSE: The following criteria have been prepared as a guide for the design of supplemental treatment processes. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) Exceptions. This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(3) Phosphorus Removal by Chemical Treatment.

(A) General.

1. Method. Addition of line or the salts of aluminum or iron may be used for the chemical removal of soluble phosphorus. The phosphorus reacts with the calcium, aluminum or iron ions to form insoluble compounds. These insoluble compounds may be coagulated with or without the addition of a coagulant aid such as polyelectrolyte to facilitate separation by sedimentation.

2. Design basis. Laboratory, pilot or full scale trial of various chemical feed systems and treatment processes are recommended to determine the performance level achievable, cost-effective design criteria and ranges of chemical dosages required. Systems shall be designed with sufficient flexibility to allow for several operational adjustments in chemical feed point location, chemical feed rates and for feeding alternate chemical compounds.

(B) Process Requirements.

1. Dosage. The chemical dosage required shall include the amount needed to react with the phosphorous in the wastewater, the amount required to drive the chemical reaction to the desired state of completion and the amount required due to inefficiencies in mixing or dispersion. Excessive chemical dosage should be avoided.

2. Chemical selection. The choice of lime or the salts of aluminum or iron should be based on the wastewater characteristics and the economics of the total system. When lime is used it may be necessary to neutralize the high pH prior to subsequent treatment in secondary biological systems or prior to discharge in those flow schemes where lime treatment is the final step in the treatment process.

3. Chemical feed points. Selection of chemical feed points shall include consideration of the type of chemicals used in the process, necessary reaction times between chemical and polyelectrolyte additions, and the type of wastewater treatment processes and components utilized. Considerable flexibility in feed point location should be provided, and multiple feed points are recommended.

4. Flash mixing. Each chemical must be mixed rapidly and uniformly with the flow stream. Where separate mixing basins are provided, they should be equipped with mechanical mixing devices. The detention period should be at least thirty (30) seconds.

5. Flocculation. The particle size of the precipitate formed by chemical treatment may be very small. Consideration should be given in the process design to the addition of synthetic polyelectrolytes to aid settling. The flocculation equipment should be adjustable in order to obtain optimum flow growth, control deposition of solids and prevent floc destruction.

6. Liquid—solids separation. The velocity through pipes or conduits from flocculation basins to settling basins should not exceed 1.5 feet per second (0.46 m/s) in order to minimize floc destruction. Entrance works to settling basins should also be designed to minimize floc shear. Settling basin design shall be in accordance with criteria outlined in 10 CSR 20-8.160. For the

Schedule JAM-5

design of a sludge handling system, special consideration should be given to the type and volume of sludge generated in the phosphorus removal process.

7. Filtration. Effluent filtration shall be considered where effluent phosphorus concentrations of less than one (1) mg/l must be achieved.

(C) Feed Systems.

1. Location. All liquid chemical mixing and feed installations should be installed in corrosion-resistant pedestals and elevated above the highest liquid level anticipated during emergency conditions. Lime feed equipment should be located so as to minimize the length of slurry conduits. All slurry conduits shall be accessible for cleaning.

2. Liquid chemical feed system. Liquid chemical feed pumps should be of the positive displacement type with variable feed rate control. Pumps shall be selected to feed the full range of chemical quantities required for the phosphorus mass loading conditions anticipated with the largest unit out-of-service. Screens and valves shall be provided on the chemical feed pump suction lines. An air break or antisiphon device shall be provided where the chemical solution discharges to the transport water stream to prevent an induction effect resulting in overfeed. Consideration shall be given to providing pacing equipment to optimize chemical feed rates.

3. Dry chemical feed system. Each dry chemical feeder shall be equipped with a dissolver which is capable of providing a minimum five (5)-minute retention at the maximum feed rate. Polyelectrolyte feed installations should be equipped with two (2) solution vessels and transfer piping for solution makeup and daily operation. Makeup tanks shall be provided with an eductor funnel or other appropriate arrangement for wetting the polymer during the preparation of the stock feed solution. Adequate mixing should be provided by a large diameter, low-speed mixer.

(D) Storage Facilities.

1. Size. Storage facilities shall be sufficient to insure that an adequate supply of the chemical is available at all times. Exact size required will depend on size of shipment, length of delivery time and process requirements. Storage for a minimum of ten (10) days' supply should be provided.

2. Location. The liquid chemical storage tanks and tank fill connections shall be located within a containment structure having a capacity exceeding the total volume of all storage vessels. Valves on discharge lines shall be located adjacent to the storage tank and within the containment structure. Auxiliary facilities, including pumps and controls, within the containment area shall be located above the highest anticipated liquid level. Containment areas shall be sloped to a sump area and shall not contain floor drains. Bag storage should be located near the solution makeup point to avoid unnecessary transportation and housekeeping problems.

3. Accessories. Platforms, ladders and railings should be provided as necessary to afford convenient, safe access to all filling connections, storage tank entries and measuring devices. Storage tanks shall have reasonable access provided to facilitate cleaning.

(E) Other Requirements.

1. Materials. All chemical feed equipment and storage facilities shall be constructed of materials resistant to chemical attack by all chemicals normally used for phosphorous treatment.

2. Temperature/humidity and dust control. Precautions shall be taken to prevent chemical storage tanks and feed lines from reaching temperatures likely to result in freezing or chemical crystallization at the concentrations employed. A heated enclosure or insulation may be required. Consideration should be given to temperature, humidity and dust control in all chemical feed room areas.

3. Cleaning. Consideration shall be given to the accessibility of piping. Piping should be installed with plugged wyes, tees or crosses at changes in direction to facilitate cleaning.

4. Drains and drawoff. Above-bottom drawoff from chemical storage or feed tanks shall be provided to avoid withdrawal of settled solids into the feed system. A bottom drain shall also be installed for periodic removal of accumulated settled solids.

(F) Hazardous Chemical Handling. The requirements of 10 CSR 20-8.140(9)(A) shall be met.

(G) Sludge Handling.

1. General. Consideration shall be given to the type and additional capacity of the sludge handling facilities needed when chemicals are used.

2. De-watering. Design of de-watering systems should be based, where possible, on an analysis of the characteristics of the sludge to be handled. Consideration should be given to the ease of operation, effect of recycle streams generated, production rate, moisture content, de-waterability, final disposal and operating costs.

(4) High Rate Effluent Filtration.

(A) General.

1. Applicability. Granular media filters may be used as a tertiary treatment device for the removal of residual suspended solids from secondary effluents. Where effluent suspended solids requirements are less than ten (10) mg/l, where secondary effluent quality can be expected to fluctuate significantly or where filters follow a treatment process where significant amounts of algae will be present, a pretreatment process such as chemical coagulation and sedimentation or other acceptable process should precede the filter units. Pretreatment units shall meet the applicable requirements of section (3) of this rule.

2. Design consideration. Care should be given in the selection of pumping equipment ahead of filter units to minimize shearing of floc particles. Consideration should be given in the plant design to providing flow equalization facilities to moderate filter influent quality and quantity.

(B) Filter Types. Filters may be of the gravity-type or pressure-type. Pressure filters shall be provided with ready and convenient access to the media for treatment or cleaning. Where greases or similar solids which result in filter plugging are expected, filters should be of the gravity-type.

(C) Filtration Rates.

1. Allowable rates. Filtration rates shall not exceed five (5) gallons per minute per square foot based on the maximum hydraulic flow rate applied to the filter units.

2. Number of units. Total filter area shall be provided in two (2) or more units, and the filtration rate shall be calculated on the total available filter area with one (1) unit out-of-service.

(D) Backwash.

1. Backwash rate. The backwash rate shall be adequate to fluidize and expand each media layer a minimum of twenty percent (20%) based on the media selected. The backwash system shall be capable of providing a variable backwash rate having a maximum of at least twenty (20) gpm/sq. ft. (13.6 $l/m^2/s$) and a minimum backwash period of ten (10) minutes.

2. Backwash. Pumps for backwashing filter units shall be sized and interconnected to provide the required rate to any filter with the largest pump out-of-service. Filtered water should be used as the source of backwash water. Waste filter backwash water shall be adequately treated.

(E) Filter Media.

1. Selection. Selection of proper media size will depend on the filtration rate selected, the type of treatment provided prior to filtration, filter configuration and effluent quality objectives. In dual or multi-media filters, media size selection must consider compatibility among media.

2. Media specifications. The following table provides a listing of the normal acceptable range of media sizes and minimum media depths. The designer has the responsibility for selection of media to meet specific conditions and treatment requirements relative to the project under consideration.

Media Sizes, mm and Minimum Depths, (in)

	Single Media	Dual Media	Multi Media
Anthracite	—	1.0–2.0 (20")	1.0–2.0 (20")
Sand	1.0–4.0 (48")	0.5–1.0 (12")	0.6–0.8 (10")
Garnet or Similar Material	—	—	0.3–0.6 (2")

Uniformity Coefficient shall be 1.7 or less.

(F) Filter Appurtenances. The filters shall be equipped with washwater troughs, surface wash or air scouring equipment, means of measurement and positive control of the backwash rate, equipment for measuring filter head loss, positive means of shutting off flow to a filter being backwashed and filter influent and effluent sampling points. If automatic controls are provided, there shall be a manual override for operating equipment, including each individual valve essential to the filter operation. The underdrain system shall be designed for uniform distribution of backwash water (and air, if provided) without danger of clogging from solids in the backwash water. Provision shall be made to allow periodic chlorination of the filter influent or backwash water to control slime growths.

(G) Reliability. Each filter unit shall be designed and installed so that there is ready and convenient access to all components and the media surface for inspection and maintenance without taking other units out-of-service. The need for housing of filter units shall depend on expected extreme climatic conditions at the treatment plant site. As minimum, all controls shall be enclosed. The structure housing filter controls and equipment shall be provided with adequate heating and ventilation equipment to minimize problems with excess humidity.

(H) Backwash Surge Control. The rate of return of waste filter backwash water to treatment units shall be controlled so that the rate does not exceed fifteen percent (15%) of the design average daily flow rate to the treatment units. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant. Surge tanks shall have a minimum capacity of two (2) backwash volumes, although additional capacity should be considered to allow for operational flexibility. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out-of-service.

(I) Backwash Water Storage. Total backwash water storage capacity provided in an effluent clearwell or other unit shall equal or exceed the volume required for two (2) complete backwash cycles.

(J) Proprietary Equipment. Where proprietary filtration equipment not conforming to the preceding requirements is proposed, data which supports the capability of the equipment to meet effluent requirements under design conditions shall be provided. The equipment will be reviewed on a case-by-case basis at the discretion of the agency.

(5) Microscreening.

(A) General.

1. Applicability. Microscreening units may be used following a biological treatment process for the removal of residual suspended solids. Selection of this unit process should consider final effluent requirements, the preceding biological treatment process and anticipated consistency of biological process to provide a high quality effluent.

2. Design considerations. Pilot plant testing on existing secondary effluent is encouraged. Where pilot studies so indicate, where microscreens follow trickling filters or lagoons, or where effluent suspended solids requirements are less than ten (10) mg/l, a pretreatment process such as chemical coagulation and sedimentation shall be provided. Care should be taken in the selection of pumping equipment ahead of microscreens to minimize shearing of floc particles. The process design shall include flow equalization facilities to moderate microscreen influent quality and quantity.

(B) Screen Material. The microfabric shall be a material demonstrated to be durable through long-term performance data. The aperture size must be selected considering required removal efficiencies, normally ranging from twenty to thirty-five (20–35) microns. The use of pilot plant testing for aperture size selection is recommended.

(C) Screening Rate. The screening rate shall be selected to be compatible with available pilot plant test results and selected screen aperture size, but shall not exceed five (5) gallons per minute per square foot (3.40 $l/m^2/s$) of effective screen area based on the maximum hydraulic flow rate applied to the units. The effective screen area shall be considered the submerged screen surface area less the area of screen blocked by structural supports and fasteners. The screening rate shall be that applied to the units with one (1) unit out-of-service.

(D) Backwash. All waste backwash water generated by the microscreening operation shall be recycled for treatment. The backwash volume and pressure shall be adequate to assure maintenance of fabric cleanliness and flow capacity. Equipment for backwash of at least eight (8) gallons per minute per linear foot (1.66 l/m/s) of screen length and sixty (60) pounds per square inch (4.22 kgf/cm^2), respectively, shall be provided. Backwash water shall be supplied continuously by multiple pumps, including one (1) standby and should be obtained from microscreened effluent. The rate of return of waste backwash water to treatment units shall be controlled so that the rate does not exceed fifteen percent (15%) of the design average daily flow rate to the treatment plant. The hydraulic and organic load from waste backwash water shall be considered in the overall design of the treatment plant. Where waste backwash water is returned for treatment by pumping, adequate pumping capacity shall be provided with the largest unit out-of-service. Provisions should be made for measuring backwash flow.

(E) Appurtenances. Each microscreen unit shall be provided with automatic drum speed controls with provisions for manual override, a bypass weir with an alarm for use when the screen becomes blinded to prevent excessive head development and means for de-watering the unit for inspection and maintenance. Bypassed flows must be segregated from water used for backwashing. Equipment for control of biological slime growths shall be provided. The use of chlorine should be restricted to those installations where the screen material is not subject to damage by the chlorine.

(F) Reliability. A minimum of two (2) microscreen units shall be provided, each unit being capable of independent operation. A supply of critical spare parts shall be provided and maintained. All units and controls shall be enclosed in a heated and ventilated structure with adequate working space to provide for ease of maintenance.

AUTHORITY: section 644.026, RSMo 1986. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.220 Land Treatment

PURPOSE: The following criteria have been prepared as a guide for the design of land

Schedule JAM-5

treatment systems. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete treatment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission as regards adequacy of design, submission of plans, approval of plans and approval of completed sewage works. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. These criteria are taken largely from Great Lakes-Upper Mississippi River Board of State Sanitary Engineers ***Recommended Standards for Sewage Works*** *and are based on the best information presently available. These criteria were originally filed as 10 CSR 20-8.030. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to consulting engineers and city engineers. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that names can be added to the mailing list.*

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(1) Definitions.

(A) Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned unless justification is presented for deviation from the requirements. Other terms, such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(B) Land treatment is the application of wastewater at rates up to the maximum amount which can be renovated by the soil—plant filter without detrimental effects to surface or groundwater soils or crops.

(C) Wastewater reuse is the application of wastewater for maximum economic return from the cropping system. Application rates will approximate the irrigation deficit and normally will not exceed twelve inches (12") (30 cm) per year.

(2) Exceptions.

(A) This rule shall not apply to facilities designed for twenty-two thousand five hundred (22,500) gallons per day (85.4 m^3) or less (see 10 CSR 20-8.020 for the requirements for those facilities).

(B) This rule shall not apply to land application systems designed for wastewater reuse. Due to the low application rates, little need for regulation exists at this time.

(3) Preliminary Considerations. Land treatment is the application of wastewater at rates not to exceed the maximum which can be renovated by the soil and vegetation without detrimental effects to surface or groundwater, soils or crops. Land treatment installations are to be used where the waste contains pollutants which can be successfully renovated through organic decomposition and the adsorptive, physical and chemical reactions in the soil and vegetation. The land treatment of wastewater may recharge the local groundwater or reemerge into streams; therefore, the quality, direction and rate of movement and local use of the groundwater, present and future, are important considerations in evaluating a proposed site. It is essential to maintain an aerated zone in the soil to provide good vegetative growth and removal of nutrients. A groundwater mound may develop after the system is in use. Major factors in the design of land treatment systems are topography, soils, geology, hydrology, weather, agricultural practice, crop, use of crop, adjacent land use, equipment selection and installation.

(4) Design Report. The design report shall include maps and diagrams as noted in the following. It shall also include any additional material that is pertinent about the location, geology, topography, hydrology, soils, areas for future expansion and adjacent land use.

(A) Location.

1. A copy of the USGS topographic map of the area (seven and one-half (7 1/2)-minute series where published), similar map or aerial photograph showing the exact boundaries of the spray field.

2. A topographic map of the total area under consideration by the applicant at a scale of approximately one inch to fifty feet (1":50') (2.54:15.2 cm) with appropriate contour interval. It should show all buildings, the waste disposal system, the spray field boundaries and buffer zone. An additional map should show the spray field topography in detail with a contour interval of two feet (2') (61 cm) and include buildings and land use on adjacent lands within one-fourth (1/4) mile of the project boundary.

3. Water supply wells which might be affected shall be located and identified as to uses—for example, potable, industrial, agricultural and class of ownership; for example, public, private, etc.

4. All abandoned wells, shafts, etc., where possible, should be located and identified. Pertinent information thereon shall be furnished.

(B) Geology.

1. Geologic formation's name and the rock types at the site.

2. Degree of weathering of the bedrock.

3. Character and thickness of the surficial deposits.

4. Local bedrock structure including the presence of faults, fractures and joints.

5. The presence of any solution openings and sinkholes in carbonate terrain.

6. The source of the information in (4)(B)1.–5. must be indicated.

(C) Hydrology.

1. The depth to seasonal and permanent highwater tables (perched and/or regional) must be given, including an indication of seasonal variations.

2. The direction of groundwater movement and the point(s) of discharge must be shown on one (1) of the attached maps.

3. Chemical analyses indicating the quality of groundwater at the site must be included.

4. Indicate the source of the data in (4)(C)1.–3.

5. The following information shall be provided from existing wells and from the test wells as may be necessary:

A. Construction details—where available. Depth, well log, pump capacity, static levels, pumping water levels, casing, grout material and the other information as may be pertinent; and

B. Groundwater quality. For example, nitrates, total nitrogen, chlorides, sulfates, pH, alkalinities, total hardness, coliform bacteria and metal ions.

6. A minimum of one (1) groundwater monitoring well, where deemed necessary by the DGLS, must be drilled in each dominant direction of groundwater movement and between the project site and public well(s) and/or high capacity private wells with provision for sampling at the surface of the water table and at five feet (5') (1.5 m) below the water table at each monitoring site. The location and construction of the monitoring well(s) must be approved by the agency. These may include one (1) or more of the test wells where appropriate.

(D) Evaluation of Effluent to be Applied.

Representative samples are essential to properly evaluate the effluent. Where the discharge is from a sewage treatment plant, twenty-four (24)-hour samples proportioned to the rate of flow will be needed to obtain a representative sample. In cases where the effluent is stored for several days or longer, a single sample of the effluent will suffice. Analyses which will be of major importance will be for total suspended solid (TTS), a volatile suspended solid (VSS), sodium, calcium, magnesium, electrical conductivity (EC), nitrogen, phosphorous, metal ions and fluoride. The sodium absorption ratio (SAR) should be calculated from sodium, calcium and magnesium determination.

(E) Soils. All soils investigation should be performed by a qualified soil scientist.

1. A soils map should be furnished of the spray field, indicating the various soil types. This may be included on the large-scale topographic map. Soils information can normally be secured through the USDA Soil Conservation Service.

2. The soils should be named and their texture described.

3. Slopes and agricultural practice on the spray field are closely related. Slopes on cultivated fields should be limited to four percent (4%) or less. Slopes on sodded fields should be limited to eight percent (8%) or less. Forested slopes should be limited to eight percent (8%) for year-round operation but some seasonal operation slopes up to fourteen percent (14%) may be acceptable.

4. The thickness of soils should be indicated. Indicate how determined.

5. Data should be furnished on the exchange capacity of the soils. In cases of industrial wastes particularly, this information must be related to special characteristics of the wastes.

6. Information must be furnished on the internal and surface drainage characteristics of the soil materials. Location and depths to impermeable or restricted horizons should be indicated.

7. Proposed application rates should take into consideration the drainage and permeability of the soils and the distance to the water table.

(F) Agricultural Practice.

1. The present and intended soil-crop management practices, including forestation, shall be stated.

2. Pertinent information shall be furnished on existing drainage systems.

3. When cultivated crops are anticipated, a cropping and harvesting program by a qualified agronomist shall be included.

(G) Adjacent Land Use.

1. Present and anticipated use of the adjoining lands must be indicated. This information can be provided on one (1) of the maps and may be supplemented with notes.

2. The plan shall show existing and proposed screens, barriers or buffer zones to prevent blowing spray from entering adjacent land areas.

3. If expansion of the facility is anticipated, the lands which are likely to be used for expanded spray fields must be shown on the map.

(5) System Design.

(A) Treatment Before Land Application. The treatment of wastewater prior to application shall be adequate to prevent nuisance conditions from occurring in the treatment facility, in the storage basins or on the application site. When spray application is to be used, the system must also minimize the aerosol spread of pathogen. A primary lagoon cell loaded at a rate not to exceed thirty-four pounds (34 lbs.) BOD_5/acre/day (38 kilograms BOD_5/hectare/day) will be considered adequate to avoid nuisance conditions. Detention time of sixty (60) days or greater will be considered adequate to achieve pathogen reduction to acceptable levels. Other treatment methods may be used to meet these requirements and will be reviewed on a case-by-case basis.

(B) Storage Requirements. Storage shall be provided for the maximum capacity required to accommodate wastewater flows in excess of quantities which can be irrigated during the wettest year in ten (10). Computations for storage shall consider possible increases in wastewater flow during wet weather. If discharge to surface waters is permitted during portions of the year, storage facilities should be adequate to store excess wastewater flow during the period when discharge is not permitted. National Weather Service records should be used to estimate the number of days that weather will prevent the application of wastewater to the land.

(C) Application Rates. Application rates shall be determined for each individual site based on topography, soils, geology, hydrology, weather, agricultural practice, adjacent land use and application method. A balance calculation for water and each significant parameter should be prepared to show that the system performance meets the requirements of 10 CSR 20-7.031 Water Quality Standards. The agency will consider comments from the Division of Geology and Land Survey, the Soil Conservation Service and University of Missouri-Extension Division in evaluating the proposed application rate.

(6) System Monitoring. An appropriate monitoring system shall be provided to determine the quality of water leaving the land treatment site and entering surface and/or ground water. Analysis of soil and plant tissue samples may be required to monitor the effect of the wastewater on the soil and crop.

(7) Fencing. The project area shall be enclosed with a suitable fence to preclude livestock and discourage trespassing. A vehicle access gate of sufficient width to accommodate mowing equipment should be provided. All access gates should be provided with locks.

(8) Warning Signs. Appropriate signs should be provided along the fence around the project boundaries to designate the nature of the facility and advise against trespassing.

AUTHORITY: section 644.026, RSMo Supp. 1988. Original rule filed Aug. 10, 1978, effective March 11, 1979.*

**Original authority: 644.026, RSMo 1972, amended 1973, 1987, 1993.*

10 CSR 20-8.300 Manure Storage Design Regulations

PURPOSE: This rule sets forth criteria prepared as a guide for the design of manure management systems at concentrated animal feeding operations. This rule shall be used together with 10 CSR 20-6.300 Concentrated Animal Feeding Operations. This rule reflects the minimum requirements of the Missouri Clean Water Commission in regard to adequacy of design, submission of plans, and approval of plans. It is not reasonable or practical to include all aspects of design in this standard. The design engineer should obtain appropriate reference materials which include but are not limited to: copies of ASTM International standards, design manuals such as Water Environment Federation's Manuals of Practice, and other design manuals containing principles of accepted engineering practice. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation.

PUBLISHER'S NOTE: The secretary of state has determined that the publication of the entire text of the material which is incorporated by reference as a portion of this rule would be unduly cumbersome or expensive. This material as incorporated by reference in *this rule shall be maintained by the agency at its headquarters and shall be made available to the public for inspection and copying at no more than the actual cost of reproduction. This note applies only to the reference material. The entire text of the rule is printed here.*

(1) Definitions.

(A) Definitions as set forth in the Missouri Clean Water Law, Chapter 644, Concentrated Animal Feeding Operation (Hog Bill) section 640.703, RSMo, 10 CSR 20-2.010, and 10 CSR 20-6.300 shall apply to the terms in this rule unless otherwise defined by subsection (1)(B) below.

(B) Other applicable definitions are as follows:

1. Design storage period—The calculated number of days that will fill the manure storage structure from the lower to the upper operating level during a period of average rainfall minus evaporation (R-E).

A. For a design storage period of fewer than three hundred sixty-five (365) days, the largest consecutive average monthly R-E, corresponding with the number of months of the storage period, shall be used.

B. For multiple storage stages, the storage period is the sum of available storage days in each stage;

2. Freeboard—The elevation difference between the bottom of the spillway to the top of the berm for an earthen manure storage basin;

3. Groundwater table—The seasonal high water level occurring beneath the surface of the ground, including underground watercourses, artesian basins, underground reservoirs and lakes, aquifers, other bodies of water located below the surface of the ground, and water in the saturated zone. For the purposes of this rule, groundwater table does not include the perched water table;

4. Manure—The fecal and urinary excretion of animals and process wastewater and dry process waste as defined in 10 CSR 20-6.300(1)(B);

5. Missouri Concentrated Animal Feeding Operation Nutrient Management Technical Standard (NMTS)—The current version of the technical standard published by the department;

6. Rainfall minus evaporation (R-E)—The average depth of monthly liquid precipitation minus evaporation as published in the most recent National Weather Service Climate Atlas for the geographical region of the proposed structure;

7. Safety depth—One foot (1') of liquid depth or the depth needed to hold the volume of the ten- (10-) year, ten- (10-) day storm, whichever is greater;

8. Solid manure—Manure that can be stacked without free flowing liquids;

9. Storage volume—The volume of manure between the lower and upper operating levels; and

10. Ten- (10-) year, ten- (10-) day storm—The depth of rainfall occurring in a ten- (10-) day duration over a ten- (10-) year return frequency as defined by the most recent publication of the National Weather Service Climate Atlas for the geographical region of the proposed manure storage structure.

(2) General.

(A) Applicability. This rule shall apply to new or expanding concentrated animal feeding operations (CAFOs) that commence construction on or after April 30, 2012.

(B) These design regulations may also be applicable to other types of agricultural waste management systems regulated by the department. Other facilities that wish to use this regulation when preparing a permit application shall first obtain written approval from the department.

(C) Careful consideration should be given to the type of storage, treatment, and land application before choosing a final system design. Important factors to consider include: location and topography of the operation; concentration and quantity of the manure to be managed; land available for manure utilization; operating costs; and the probable type of supervision and maintenance the operation will require.

(D) New Processes, Methods, and Equipment. The policy of the department is to not obstruct the development of new methods, equipment, and management practices for manure management. The lack of inclusion in this standard of a particular type of treatment process or equipment should not be construed as precluding its use. The department will approve other types of processes or equipment under the following conditions:

1. The operational reliability and effectiveness of the process or device shall have been demonstrated with a suitably-sized prototype unit operating at its design load conditions to the extent required by the department; and

2. The department may require additional tests including:

A. Results and engineering evaluations demonstrating the efficiency of the processes or equipment; and

B. Appropriate, independent testing/evaluation conducted under the supervision of an engineer not employed by the manufacturer or developer.

(E) Deviations. Deviations from these rules may be approved by the department when engineering justification satisfactory to the department is provided. Justification must substantially demonstrate in writing and through calculations that a variation(s) from the design rules will result in either at least equivalent or improved effectiveness. Deviations are subject to case-by-case review with individual project consideration.

(3) Permit Application Documents. Applications for a construction permit, or for an operating permit that did not previously receive a construction permit, shall submit one (1) set of documents described in this section for department approval as part of the permit application process.

(A) Engineering Documents. The engineering documents shall provide the basic information, present design criteria and assumptions, examine alternate systems, where appropriate, and provide plans and specifications. The documents shall also include process description, sizing, data, controlling assumptions, and considerations for the functional operation of a manure management system. All engineering documents shall be prepared by or under the direct supervision of a registered professional engineer licensed to practice in Missouri. The department will not examine the adequacy or efficiency of the structural, mechanical, or electrical components of the manure management systems, only adherence to rules and regulations.

1. Engineering report—The following paragraphs should be utilized as a guideline for the content of the project engineering report to be submitted to the department for review and approval:

A. Letter of transmittal. A one- (1-) page letter typed on the design engineer's letterhead should be included in the submission of the report;

B. Title page. Title of project, date, operation's name and address, name and address of firm preparing the report, and seal and signature of the engineer;

C. Project location map. This map shall include state and county roads, county boundaries, and city boundaries, and show the location of the proposed project;

D. The table of contents shall include section and subsection headings. All pages of the report shall be numbered and the table of contents shall reference these numbers;

E. Narrative project summary. This section should provide an explanation of any existing conditions at the operation and a summary of the proposed modifications to the operation;

F. Technical information and design criteria. This section should include the design data, calculations, all assumptions, and all relevant information used to justify the design. If the engineering documents contain known deviations from the design criteria contained in this rule, documentation and justification for the deviation should be submitted with the design criteria. The following items should be included:

(I) Each animal type and number within the production area, the maximum design animal capacity, and the average weight for each animal type;

(II) A detailed explanation of the process by which manure is deposited, handled, managed, and transferred within the operation;

(III) Calculations showing the estimated annual amount of manure generated at the production area.

(a) Where possible, design manure volume shall be based on past operating records or operating data from facilities with similar feed inputs and animal characteristics. Documentation of these volumes shall be included.

(b) If operating data is not available, the design manure volume shall be estimated using the most recent edition of a research-based reference. The reference name, edition, and data shall be included;

(IV) Design calculations justifying the size of manure storage structures. For anaerobic treatment lagoons, the volume of treatment shall be based on the geographical region of the proposed structure and calculated using the most recent edition of a research-based reference. The reference name, edition, and data shall be included;

(V) Depth and volume tables on at least one-foot (1') increments for all manure storage basins with design operating depths clearly identified;

(VI) Collection, treatment, and disposal of all domestic wastewater flows associated with the operation; and

(VII) If applicable, justifications for constructing an uncovered manure storage structure. Covered storages are preferred due to the lower risk of environmental damage from excessive rainfall;

G. Soils report/soils information. The engineering report shall contain county soil survey information for the soil types and characteristics of the production areas. Unless required otherwise by the department, soils information shall include soil series name, soil texture, soil permeability, and water-holding capacity. If a county soils map is available, the approximate boundaries of the different soils shall be shown. When applicable, the engineering report shall incorporate all recommendations by the Division of Geology and Land Survey. Any soil boring logs shall also be included in the report; and

H. Operation and maintenance plan—An operation and maintenance plan shall be provided to explain the key operating procedures. At a minimum, the plan shall address operation and maintenance of mechanical equipment.

2. General layout drawings. Plans shall include both an aerial and a topographic map or drawing that shows the spatial location and extent of the production area. Each drawing or map must be easily readable and include a visual scale, a north directional arrow, a fixed geographic reference point, and the date the drawing or map was completed. Each drawing or map shall include the following:

A. All confinement barns, open lots, manure storage, and control structures, along with the other various components of the operation such as areas designated for stockpiling, composting, and for the management of animal mortalities;

B. The source of the operation's water supply and all wells within three hundred feet (300') of the production area; and

C. The location of all surface water features within the boundaries or immediately adjacent to the production area.

3. Construction plan drawings. Plan drawings shall include the following:

A. The name of the operation and the scale in feet, a graphic scale, a north directional arrow, and the signed and dated engineer's seal;

B. The plans shall be clear and legible. They shall be drawn to a scale which will permit all necessary information to be plainly shown. The size of the plans generally should not be larger than thirty inches by forty-two inches (30" × 42"), with a preference for smaller sizes;

C. Locations of all test borings with date shall be shown on the plans;

D. Detail plans shall consist of plan views, elevations, sections, and supplementary views which, together with the specifications and general layouts, provide the working information for the construction of the containment facilities; and

E. Include dimensions and relative elevations of structures, the location and outline form of equipment, storage tanks, location and size of piping, and ground elevations.

4. Specifications. When specifically directed by the department, technical specifications shall accompany the plans.

(B) Other Documents.

1. Neighbor notice and buffer verification. One (1) copy of the neighbor notice letter and proof that the notification has been sent. A map shall also be included that meets the requirements of 10 CSR 20-6.300(3)(C)4.

2. Geohydrologic evaluation by the department's Division of Geology and Land Survey. This is required only for proposed earthen manure storage basins.

3. An emergency response plan, if not included in the nutrient management plan.

(C) Nutrient Management Plan. The application shall include a nutrient management plan that meets the specifications of the NMTS and the requirements of 10 CSR 20-6.300(5). This plan shall include:

1. Land application maps—An aerial, topographic, and soils map that shows the spatial boundaries of planned land application areas. The aerial map(s) must clearly show the following within three hundred feet (300') beyond the field boundaries:

A. The location and extent of all permanent flowing streams, intermittent flowing streams, wetlands, and sinkholes;

B. Open tile line intake structures that will not be plugged during land application;

C. Lakes, reservoirs, or other private and publicly-owned water impoundments;

D. Private and public wells;

E. Public roads;

F. Public use areas;

G. Public dwellings; and

H. Property boundaries; and

2. All additional components necessary to prove compliance with 10 CSR 20-6.300(5).

(4) Revisions to Approved Plans. Deviations from approved plans affecting storage capacity, flow, or location must be approved in writing before these changes are made. Revised plans shall be submitted well in advance of any construction work which will be affected by these changes to allow sufficient time for review and approval. Structural revisions or other minor changes not affecting storage capacity, flow, or location will be permitted during construction without approval. As-built plans clearly showing these alterations shall be submitted to the department after the completion of the work.

(5) Location.

(A) Protection from Flooding—Manure storage structures, confinement buildings, open lots, composting pads, and other manure storage areas in the production area shall be protected from inundation or damage due to the one hundred- (100-) year flood.

Schedule JAM-5

(B) The minimum setback distances from manure storage structures, manure storage areas, confinement buildings, open lots, or mortality composters are as follows:

1. Ten feet (10') to public water supply pipelines;

2. Fifty feet (50') to property lines;

3. Fifty feet (50') to public roads;

4. One hundred feet (100') to wetlands, ponds, or lakes not used for human water supply;

5. One hundred feet (100') to gaining streams (classified or unclassified; perennial or intermittent);

6. Three hundred feet (300') to human water supply lakes or impoundments; and

7. Three hundred feet (300') to losing streams (classified or unclassified; perennial or intermittent) and sinkholes.

(C) Distances from earthen manure storage basins shall be measured from the outside edge of the top of the berm.

(D) Separation distance from wells for manure storage structures or confinement buildings shall be in accordance with 10 CSR 23-3.010.

(E) An all-weather access road shall be provided from a public road to the Animal Feeding Operation (AFO). Sufficient room shall be provided at the site to permit turning vehicles around. In determining the type of roadway and method of construction, consideration shall be given to the types of vehicles and equipment necessary to maintain and operate the AFO.

(6) Manure Storage Sizing.

(A) No Discharge Requirement. All manure storage structures shall comply with the design standards and effluent limitations of 10 CSR 20-6.300(4).

(B) Design Storage Period.

1. The recommended design storage period is three hundred sixty-five (365) days.

2. The minimum design storage period for liquid manure and for solid manure that will be used in the land application area is one hundred eighty (180) days.

3. Solid manure to be sold or used as bedding shall have a minimum design storage period of ninety (90) days unless justification is given for a shorter time period.

4. An operation proposing an uncovered, liquid manure storage structure, *with less than three hundred sixty-five (365) days of storage*, will be evaluated based upon the ability to actively manage the system. The following, at a minimum, will be evaluated:

A. Does the AFO owner(s) have at least fifty percent (50%) ownership in the land application equipment;

B. Does the AFO owner(s) own at least fifty percent (50%) of the needed annual land application area;

C. Is at least fifty percent (50%) of the needed annual land application area in permanent, perennial vegetation; and

D. Is the available equipment and labor capable of lowering the liquid level by ten percent (10%) of the storage volume in one (1) working day?

5. The design storage period must be accounted for in the Nutrient Management Plan.

6. The minimum design storage period for anaerobic treatment lagoons without an impermeable cover is three hundred sixty-five (365) days.

(C) New Class I swine, veal, or poultry operations shall evaluate proposed uncovered manure storage structures in accordance with applicable federal regulation as set forth in 40 CFR 412.46(a)(1), November 20, 2008, which is hereby incorporated by reference, without any later amendments or additions, as published by the Office of the Federal Register, National Archives and Records Administration, Superintendent of Documents, Pittsburgh, PA 15250-7954.

(D) Sizing Manure Storage Structures.

1. The structure shall be designed to hold all inputs, between the upper and lower operating levels, anticipated during the design storage period. This typically includes:

A. Animal manure;

B. Bedding material;

C. Wash water;

D. Flush water (excluding recycled flush water);

E. Cooling water for animals or from equipment; and

F. Runoff from pervious and impervious areas, due to average rainfall.

2. Uncovered liquid storages shall also include:

A. R-E from the surface of the structure, held between the operating levels; and

B. Safety depth, above the upper operating level.

3. Tanks and pits shall also include six inches (6") of depth below the lower operating level for incomplete removal allowance unless there is adequate justification for not including this depth.

4. Earthen manure storage basins shall also include:

A. Freeboard of at least one foot (1'). Two feet (2') is required for structures that receive storm water from open lots larger than the surface area of the storage structure;

B. Two feet (2') of permanent liquid depth below the lower operating level. Anaerobic treatment volume greater than two feet (2') will satisfy this requirement;

C. Sludge accumulation volume; and

D. Anaerobic treatment lagoons shall include treatment volume below the lower operating level.

(7) Construction and Maintenance of Earthen Manure Storage Basins.

(A) Geohydrologic Evaluation. A geohydrologic evaluation of the proposed earthen manure storage basin prepared by the department's Division of Geology and Land Survey shall be submitted. To obtain a geohydrologic evaluation of the proposed site, the engineer shall submit the appropriate request form to the Division of Geology and Land Survey. All potential basin sites will receive two (2) ratings from the geohydrologic evaluation. The ratings will infer the relative geological limitations for designing and constructing a basin at the site in question.

1. Collapse potential rating. If the geohydrologic evaluation gives a severe rating for collapse potential, an earthen basin is not acceptable. Concrete or steel structures or an alternate site should be considered.

2. Overall geologic limitations rating. Sites that have a severe rating for the overall geologic limitations but a slight or moderate collapse potential will be reviewed on a case-by-case basis. The department may require artificial liners or additional geotechnical exploration and design implementation and/or post-construction testing in these situations.

(B) Detailed Soils Investigation.

1. A detailed soils investigation is required to substantiate feasibility. The quantity and quality of soil materials on-site and from a borrow area must be identified and evaluated for use in the basin and/or liner.

2. Exploration shall be sufficient to identify and define the quantity and quality of the soil material. The use of test pits, split spoon (barrel), or thin-walled tube sampling or a combination of these techniques may be used depending on the total area of investigation and the depth to which exploration is needed. The following information, in whole or in part, is required:

A. Atterburg limits;

B. Standard proctor density (moisture/density relationships);

C. Coefficient of permeability (undisturbed and remolded);

D. Depth to bedrock;

E. Particle size analysis; and

F. Depth to seasonal high groundwater table.

3. Information gathered from the investigation shall be presented on a map drawn to

scale. Slope, location, and other surface features should also be included. The soil profile should be shown of the representative soil material. Copies of original boring and other soil test logs shall also be included. An interpretation of the collected data shall be incorporated into the report. Any site constraints and how they will be dealt with should be discussed.

(C) Shape and Location.

1. Shape of cells. The shape of all cells should be such that there are no narrow or elongated portions. Round, square, or rectangular cells (length not exceeding three (3) times the width) are recommended. No islands, peninsulas, or coves shall be permitted.

2. Constant elevation of floor. The floor of the structure shall be a consistent elevation. Finished elevations shall not be more than three inches (3") above or below the average elevation of the floor.

3. Distance to groundwater and bedrock. The floor of the basin shall be at least four feet (4') above the high water table or the water table as modified by subsurface drainage. In addition, the floor shall be at least two feet (2') above bedrock. For perched water tables, a curtain drain with a positive outlet may be installed around the structure to permanently lower the water table.

(D) Slopes. Inner and outer berm slopes shall not be steeper than three to one (3:1), horizontal to vertical. Inner slopes shall not be flatter than four to one (4:1). Consideration may be given to steeper inner slopes provided special attention is given to stabilizing the slope with rip-rap, concrete, or other rigid materials. These stabilization methods shall be specified. The flatness of the outer slope is of no concern provided surface water can be diverted around the lagoon. Long outer slopes should be flatter than three to one (3:1) to assist in safe mowing of vegetation.

(E) Berm Construction and Width.

1. Soil used in constructing the basin floor (not including clay liner) and berm cores shall be relatively incompressible, tight, and compacted between two percent (2%) below and four percent (4%) above the optimum water content and compacted to at least ninety percent (90%) standard proctor density.

2. Compaction of lifts for berm construction shall not exceed twelve inches (12").

3. Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift.

4. The minimum top of berm width shall be four feet (4'). If large equipment is to be used for mowing, a top minimum width of at least eight feet (8') shall be provided.

(F) Emergency Spillway. To prevent overtopping and cutting of berms, an emergency overflow shall be provided. The spillway shall—

1. Be located in the location with the minimum amount of constructed earthen fill;

2. Provide passage of liquid at a safe velocity to a point outside of the berm(s);

3. Have a minimum bottom width of ten feet (10') and a minimum depth of one foot (1'); and

4. Be compacted and vegetated or otherwise constructed to prevent erosion due to possible flow.

(G) Compacted Clay Liner. The following criteria are for design and construction of soil liners. Engineering reports, plans, and specifications should address these criteria.

1. Soils information. The soils used for construction of an earthen basin liner should meet the following minimum specifications:

A. Be classified under the Unified Soil Classification Systems as CL, CH, GC, or SC;

B. Allow more than fifty percent (50%) passage through a Number 200 sieve;

C. Have a liquid limit equal to or greater than thirty (30);

D. Have a plasticity index equal to or greater than twenty (20); and

E. Have a coefficient of permeability equal to or less than 1×10^{-7} centimeters per second (cm/sec) when compacted to ninety percent (90%) of standard proctor density with the moisture content between two percent (2%) below and four percent (4%) above the optimum moisture content.

2. Liner construction.

A. Construction shall include scarification and compaction of base material between two percent (2%) below and four percent (4%) above the optimum water content and compacted to at least ninety percent (90%) standard proctor density.

B. Compaction of lifts shall not exceed six inches (6"). Maximum rock size should not exceed one-half (1/2) of the thickness of the compacted lift.

C. The completed seal shall be maintained at or above the optimum water content until the basin is prefilled with water in accordance with this section of the rule.

3. Permeability. All earthen basins shall be sealed so that seepage loss through the seal is minimized. The basin seal shall cover the floor and extend up the inner slope to where the side slope intersects with the top of the berm.

A. The design permeability of the basin seal shall not exceed five hundred (500) gallons per acre per day in areas where potable groundwater might become contaminated or when the wastewater contains industrial contributions of concern. Design seepage rates up to three thousand five hundred (3,500) gallons per acre per day may be considered in other areas where potable groundwater contamination is not a concern, provided that the cells will maintain adequate water levels to provide treatment and avoid nuisance conditions.

B. Liner thickness. The minimum thickness of the liner is twelve inches (12"). For soils which have a coefficient of permeability greater than 1×10^{-7} centimeter per second (cm/sec), unusual depth or potable ground water contamination potential, liner thickness of more than twelve inches (12") may be required. The following equation shall be used to determine minimum seal thickness:

$$t = (H \times K)/\ 5.4 \times 10^{-7} \text{cm/sec}$$

where

K = permeability coefficient of the soil in question;

H = head (maximum water level depth) of water in the basin; and

t = thickness of the soil seal.

Units for H and t may be English (feet) or metric (meters); however, they must be the same.

4. Soil additives. Bentonite, soda ash, or other sealing aids may be used to achieve an adequate seal in systems using soil. The design shall include information on the type of soil additive and the method of application.

(H) Prefilling. The basin shall be prefilled in order to protect the liner, prevent weed growth, reduce odor, allow measurement of percolation losses, and maintain moisture content of the seal. However, the berms must be completely prepared before the introduction of water. If the clay liner is allowed to dry, the liner must be scarified and recompacted as described in this section of the rule.

(I) Protection of Berms.

1. Livestock, burrowing animals, and woody vegetation must be excluded from basins to protect the integrity of the berms and liners.

2. The berms, diversion ditches, and terraces shall be seeded and a good vegetative cover established to minimize erosion and aid in weed control. The inner berms should be seeded down to the upper operating level of the structure. Where the structure is not anticipated to reach its upper operating level during the first growing season, consideration

Schedule JAM-5

should be given to further seeding on the berm slope. Long rooted grasses shall not be used for seeding of berms. Fertilization needs, mulching, and watering must be considered for all basins to ensure that a good growth of grass occurs rapidly and is sustained. Specifications shall detail specific amounts and variety of seeds to be used, mulching, and fertilizer requirements as appropriate and the proper time period for application to be reasonably assured that vegetative cover will be established.

3. Rip-rap or some other acceptable method of erosion control is required as a minimum around all piping entrances and exits. For aerated cell(s), the design should ensure erosion protection on the slopes and floor in the areas where turbulence will occur.

4. For basins with a surface area greater than five (5) acres, consideration shall be given to providing embankment protection from wave action.

(J) Alternative Liners. Seals consisting of asphalt, concrete, soil cement, or synthetic liners may be used provided the permeability, durability, and integrity of the proposed materials can be satisfactorily demonstrated for anticipated conditions.

(K) Percolation Losses. Measurement of percolation losses, when required, shall consider flow into and out of the lagoon, rainfall and evaporation, and changes in water level. Measured percolation losses in excess of one-sixteenth inch (1/16") per day will be considered excessive. The barrel test as described in 10 CSR 20-8.020(16) is an acceptable water balance study. Other tests will require department approval.

(L) Depth Gauges. A permanent depth measurement gauge or marker shall be installed and maintained in the basin and shall be easily readable at one-foot (1') increments or smaller. It shall clearly display the lower and upper operating levels and the spillway elevation. The gauge shall be placed in a suitable location where it is easily accessible during routine operations.

(M) Sludge Accumulation. Sludge levels shall be maintained so as to not reduce the approved storage volume of the basin.

(8) Construction of Tanks and Pits.

(A) Soils and Foundation. A thorough site investigation shall be made to determine the physical characteristics and suitability of the soil and foundation for the fabricated storage structure. The floor of the below-ground storage tanks shall be two feet (2') above the high water table unless curtain drains or interception drains are installed around the perimeter of the structure to permanently lower the water table. The drain shall be at an elevation of at least one foot (1') below the floor to permanently lower the water table. A sump or a positive outlet for the drain shall be provided.

(B) Depth Allowance for Agitation and Ventilation. An allowance of one foot (1') should be provided at the top of covered structures for agitation and/or ventilation requirements.

(C) Depth Gauges. Uncovered tanks and pits shall include a permanent depth measurement gauge or marker that is easily readable at one-foot (1') increments or smaller.

(D) Footing Drains/Perimeter Tiling. Perimeter tiling and granular backfill are required for below ground pits unless justification is given that they are not needed. Tiles should be located below the base of the outside of the footing. At least two feet (2') of granular drain material, such as pea gravel or three-quarter inch (3/4") crushed rock shall be placed around the tile. A positive outlet or sump for the drain shall be provided.

(E) Tank and pit footings are to be located at or below the maximum frost depth unless adequate justification is given that it is not needed. A compacted foundation of frost-free material such as drained granular material, extending to below frost depth, may be used as an alternate to extending the structural footing.

(F) Concrete and steel features shall be designed according to published guidelines. These guidelines must be referenced in the application packet.

(G) Watertight Requirement. Tanks and pits must be designed, constructed, and maintained to be watertight.

(9) Construction of Solid Manure Systems. This section covers the construction of poultry buildings, open lots, stacking pads, and other similar structures.

(A) Surface water shall be diverted around or away from animal confinement areas and buildings.

(B) Floors and Pads. The base of covered and uncovered lots, poultry buildings, and other solid manure storage areas can be made of concrete or other rigid, essentially watertight materials *or* from a firm, compacted, earthen base that meets the following criteria:

1. The floor shall be evaluated for suitable soils and groundwater table to a depth of four feet (4') below the proposed floor elevation;

2. The finished earthen floor shall be a minimum of two feet (2') above the apparent high water table or the water table as modified by subsurface drainage;

3. The finished earthen floor shall be at least two feet (2') above bedrock;

4. The existing soils shall have at least one (1) continuous foot of suitable soils within four feet (4') of the proposed earthen floor in order to use existing soils without amendments. Suitable soils are defined in this section as Unified Soil Classification System (USCS) class CH, MH, CL, GC, or SC and permeability group III or IV according to the United States Department of Agriculture's (USDA's) National Engineering Handbook, Agricultural Waste Management Field Handbook;

5. Existing soils can be modified using soil amendments provided that the modified soil has at least one (1) compacted, continuous foot of soil modified to meet permeability group III or IV;

6. Borrow soils can be used for the floor. Borrow soils must provide at least one (1) compacted, continuous foot of suitable soils as defined above; and

7. The use of one (1) five-foot- (5'-) deep test pit, near the center of each proposed set of four (4) buildings, or each acre, will generally be sufficient to satisfy the intent of this section.

(C) Uncovered solids storage areas must also meet the following:

1. Have an overall slope between two percent (2%) and four percent (4%) for unpaved lots;

2. Be maintained in a way that prevents ponding; and

3. Have a runoff collection structure that meets the requirements of this rule.

(D) Roofed areas of five thousand (5,000) square feet or less, that are used for mortality composting or to store solid manure, are exempt from the requirements of this section.

(10) Temporary Stockpiling of Solid Manure.

(A) Temporary stockpiling of uncovered solid manure within the production area, without runoff collection, is not allowed.

(B) Temporary stockpiling within the land applications areas shall be in accordance with the following:

1. Location.

A. Any temporary stockpiles need to be placed to prevent storm water from draining into or through the pile. If storm water does drain through the pile, a one-foot (1') berm will be required on the up-slope side of the pile.

B. No location shall be used for stockpiling for more than two (2) weeks, unless the pile is covered.

C. Separation distances shall be maintained between the stockpile and other features as follows:

(I) Three hundred feet (300') from any losing stream, well, sinkhole, water supply (for human consumption) reservoir, non-owned dwelling or residence, public building, or public use area;

(II) One hundred feet (100') from intermittent and permanent flowing streams; and

(III) Fifty feet (50') from public roads and property lines.

D. Stockpiles cannot be placed on slopes steeper than six percent (6%).

2. Size. No temporary storage site can be larger than two (2) acres.

3. Formation. All piles shall be placed so as to minimize forming pockets, hollows, or mini-dams that would collect and hold water. One (1) pile with an angle of repose so that it forms a crust and will tend to shed water off the pile will be the desirable design. If there are two (2) or more stockpiles, they should be placed far enough apart that they do not trap and hold water.

4. In no case shall runoff from a stockpile cause a violation of water quality standards.

(11) Design and Construction of Pipelines, Pump Stations, and Land Application Systems.

(A) General. Design of pipelines shall be in accordance with sound engineering principles considering the manure properties, management operations, exposure, etc.

1. The minimum pipeline capacity from storage/treatment facilities to utilization areas shall ensure the storage/treatment facilities can be emptied within the time limits stated in the nutrient management plan.

2. All pipes shall be designed to convey the required flow without plugging, based on the type of material and total solids content.

3. All pressure pipelines shall be installed at a depth sufficient to protect against freezing.

4. Pipelines shall be installed with appropriate connection devices to prevent contamination of private or public water supply distribution systems and groundwater.

5. Pumps shall be sized to transfer material at the required system head and volume. Type of pump shall be based on the consistency of the material and the type of solids. Requirements for pump installations shall be based on manufacturer's recommendations.

6. The top of all pipelines entering or crossing streams shall be at sufficient depth below the natural floor of the stream bed to protect the pipe. The top of the pipe should be a minimum of three feet (3') below the natural stream floor. Pipelines crossing streams should be designed to cross the stream as nearly perpendicular to the stream flow as possible. Aerial pipeline crossing of streams shall be in accordance with 10 CSR 20-8.120(9).

7. Buried pipeline crossings under roads shall be properly cased.

8. Potable water line and buried manure pipeline separation. There shall be no permanent physical connection between a potable water supply and buried manure pipeline or appurtenances thereto which will permit the passage of wastewater or contaminated water into the potable water supply. Whenever possible, buried manure pipelines and pump stations should be located at least ten feet (10') horizontally from any existing or proposed water line. Should local conditions prevent a lateral separation of ten feet (10'), a manure pipeline may be laid closer than ten feet (10') if it is in a separate trench or if it is in the same trench with the waterline located at one (1) side on a bench of undisturbed earth. In either case, the elevation of the top of the manure pipeline must be at least eighteen inches (18") below the base of the water line.

(B) Gravity Pipelines.

1. The minimum slope for a gravity pipe installation is one percent (1%). The design slope shall account for the head differential and the percent solids of the manure.

2. Clean-out access shall be provided for gravity pipelines at a maximum interval of one hundred fifty feet (150') unless an alternative design is approved. Gravity pipelines shall not have horizontal curves or bends except minor deflections (less than ten (10) degrees) in the pipe joints unless special design considerations are used.

3. Gravity discharge pipes used for emptying a storage/treatment structure shall have a minimum of two (2) gates or valves in series, one (1) of which shall be manually operated.

(C) Force Mains and Pressure Pipes. To minimize settling of solids in the pipeline, design velocities shall be between three (3) and six (6) feet per second.

(D) Testing. Hydro-pressure tests shall be made only after the completion of backfilling operations and after the concrete thrust blocks have set for at least thirty-six (36) hours.

1. The duration of pressure tests shall be a minimum of one (1) hour unless otherwise directed by the engineer.

2. The minimum test pressure shall be the maximum system operating pressure. All tests are to be conducted under the supervision of the engineer.

3. The pipe line shall be slowly filled with water. The specified pressure measured at the lowest point of elevation shall be applied by means of a pump connected to the pipe in a manner satisfactory to the engineer.

(E) Pump Stations.

1. Water supply protection. There shall be no physical interconnection between any potable water supply and a pump station or any of its components which under any conditions might cause contamination of a potable water supply unless otherwise approved by the department's Division of Geology and Land Survey. Manure pumping stations shall be located at least three hundred feet (300') from any potable water supply well.

2. Alarm systems. Alarm systems are required for pumping stations where a failure could cause an overflow. Alarm systems shall be activated in cases of power failure, pump failure, or any cause of high water in the wet well.

(F) Land Application Systems. The following shall be considered in the design of land application systems:

1. Any spray application equipment specified shall minimize the formation of aerosols;

2. The pumping system and distribution system shall be sized for the flow and operating pressure requirements of the distribution equipment and the application restrictions of the soils and topography;

3. Provisions shall be made for draining the pipes to prevent freezing, if pipes are located above the frost line;

4. A suitable structure shall be provided for either a portable pumping unit or a permanent pump installation. The intake to the pumping system shall provide the capability for varying the withdrawal depth. The intake elevation should be maintained twelve to twenty-four inches (12"–24") below the liquid elevation. The intake shall be screened so as to minimize clogging of the sprinkler nozzle or distribution system orifices. For use of a portable pump, a stable platform and flexible intake line with flotation device to control depth of intake will be acceptable;

5. Thrust blocking of pressure pipes shall be provided. For use of above-ground risers for sprinklers, a concrete pad and support bracing should be considered; and

6. Automatic pump or engine shut-offs, in case of pressure drop, are required.

(12) General System Details.

(A) Mechanical Equipment. Mechanical equipment shall be used and installed in accordance with manufacturers' recommendations and specifications. Major mechanical units should be installed under the supervision of the manufacturer's representative.

(B) Construction Materials. Due consideration should be given to the use of construction materials which are resistant to the

Schedule JAM-5

action of hydrogen sulfide and other corrosives frequently present in manure.

(C) Grading and Groundcover. Upon completion of construction, the ground shall be graded and reseeded to prevent erosion and the entrance of surface water into any storage structure or animal confinement area.

(D) Potable Water Supply Protection. No piping or other connections shall exist in any part of the manure management system which, under any conditions, might cause the contamination of a potable water supply.

(13) Groundwater Monitoring. An approved groundwater monitoring program may be required around the perimeter of a manure storage site and/or land application areas to facilitate groundwater monitoring. The necessity of a groundwater monitoring program, which may include monitoring wells and/or lysimeters, will be determined by the department's Division of Geology and Land Survey on a case-by-case basis and will be based on potential to contaminate a drinking water aquifer due to soil permeability, bedrock, distance to aquifer, etc. Where the Division of Geology and Land Survey has deemed groundwater monitoring necessary, a geohydrological site characterization will be required prior to the design of the groundwater monitoring program.

(14) Mortality Management.

(A) Class I operations shall not use burial as a permanent mortality management method to dispose of routine mortalities.

(B) Operations shall first receive approval from the department before burying significant numbers of unexpected mortalities and shall conduct the burial in accordance with Missouri Department of Agriculture requirements. Rendering, composting, incineration, or landfilling, in accordance with Chapter 269, RSMo Supp. 2010, shall be considered acceptable options and do not require prior approval.

AUTHORITY: sections 640.710 and 644.026, RSMo 2000. Original rule filed July 14, 2011, effective April 30, 2012.*

**Original authority: 640.710, RSMo 1996 and 644.026, RSMo 1972, amended 1973, 1987, 1993, 1995, 2000.*

10 CSR 20-8.500 Secondary Containment for Agrichemical Facilities

PURPOSE: The following criteria have been prepared as a guide for the design, construction and operation of secondary and operational area containment structures at bulk agrichemical facilities. This rule is to be used with rules 10 CSR 20-8.110–10 CSR 20-8.220 for the planning and design of the complete storage and containment facility. This rule reflects the minimum requirements of the Missouri Clean Water Commission regarding adequacy of design, submission of plans, approval of plans and approval of completed storage and containment facility. Deviation from these minimum requirements will be allowed where sufficient documentation is presented to justify the deviation. A facility need only to comply with these rules when it comes within the definition of an agrichemical facility. Any new agrichemical facility shall be in compliance with all of these rules before the commencement of any operational activities or any storage or use of agrichemicals. Upon adoption of these rules, all existing agrichemical facilities shall be in compliance with them as follows: secondary and operational area containment for pesticides—five (5) years from the date the rule is adopted; and secondary and operational area containment for fertilizers—five (5) years from the date the rule is adopted. Any facility that has a discharge of agrichemicals or process generated wastewater which results in damage to the environment may be required to take immediate steps to implement the secondary and operational containment requirements contained in this rule. All agrichemical facilities shall be registered and issued a general operating permit from the department on forms furnished by the department. Registration shall be valid for the life of the permit, terminated by the department or voluntarily withdrawn by the applicant. These criteria are based on the best information presently available and are similar to secondary containment regulations that have been implemented in other states. It is anticipated that they will be subject to review and revision periodically as additional information and methods appear. Addenda or supplements to this publication will be furnished to the regulated community. If others desire to receive addenda or supplements, please advise the Clean Water Commission so that your name can be added to the mailing list.

Editor's Note: The secretary of state has determined that the publication of this rule in its entirety would be unduly cumbersome or expensive. The entire text of the material referenced has been filed with the secretary of state. This material may be found at the Office of the Secretary of State or at the headquarters of the agency and is available to any interested person at a cost established by state law.

(1) Definitions. Definitions as set forth in the Clean Water Law and 10 CSR 20-2.010 shall apply to those terms when used in this rule, unless the context clearly requires otherwise. Where the terms shall and must are used, they are to mean a mandatory requirement insofar as approval by the agency is concerned, unless justification is presented for deviation from the requirements. Other terms such as should, recommend, preferred and the like, indicate discretionary requirements on the part of the agency and deviations are subject to individual consideration.

(2) General. A facility need only to comply with these rules when they come within the definition of an agrichemical facility. Any new agrichemical facility shall be in compliance with all of these rules before the commencement of any operational activities or any storage or use of agrichemicals. All existing agrichemical facilities shall be in compliance with these rules as follows: secondary and operational area containment for pesticides—five (5) years from the date the rule is adopted; and secondary and operational area containment for fertilizers—five (5) years from the date the rule is adopted. Any existing agrichemical facility that has a discharge of agrichemicals or process generated wastewater to the environment will be required to take immediate steps to implement the secondary and operational containment requirements contained in this rule. All agrichemical facilities shall apply for an operating permit on forms furnished by the department. Storage of bulk liquid fertilizer in a mobile container for more than thirty (30) days is prohibited unless the mobile storage container is located within a secondary containment or operational containment area. Deviation from the requirements contained in this rule will be considered by the department on a case-by-case basis. Sufficient documentation shall be submitted justifying the need for the deviation.

(3) Exceptions. The following exceptions shall apply to agrichemical facilities:

(A) This rule shall not apply to agrichemical facilities storing or handling less than the regulated quantities of agrichemicals unless an on-site evaluation by the department determines that compliance with the regulations is necessary to protect the environment.

(B) Liquid fertilizer storage tanks, that are in use when this rule is adopted, having a storage capacity greater than forty thousand (40,000) gallons shall be exempt from the requirement of installing a liner underneath the tank itself. Spill containment diking is required around these tanks. These facilities

Schedule JAM-5

shall submit to the department for approval a program outlining the monitoring, tank testing and record keeping that will be done at the facility to document that a release of agrichemicals from these tanks has not occurred either to surface or subsurface waters of the state.

(C) The prohibition of storing bulk liquid fertilizer in a mobile container for more than thirty (30) days shall not apply to barges and rail cars used solely for transporting liquid fertilizer from chemical production facilities to retail or wholesale facilities.

(D) The prohibition of burying pipes used for transferring full strength agrichemicals shall not apply to piping used solely for the loading and unloading of liquid fertilizer from barges and rail cars. These pipes shall be pressure tested on a yearly basis to certify the integrity of the pipes. Records of the pressure testing shall be kept on file at the facility and made available to department personnel upon request.

(4) Engineering services are performed in three (3) steps: engineering report or facilities plan, preparation of construction plans, specifications and contractual documents and construction compliance, inspection, administration and acceptance. These services are generally performed by engineering firms in private practice but may be performed by state or federal agencies. All reports, plans and specifications should be submitted at least sixty (60) days prior to the date upon which action by the agency is desired or in accordance with the National Pollutant Discharge Elimination System (NPDES) or other schedules. The documents should be submitted for formal approval at the appropriate times and should include the engineer's report (facilities plan) and design drawings and specifications. For unusual or complex projects, it is suggested that the engineer meet with the appropriate department staff to discuss the project and that preliminary reports be submitted for review prior to the preparation of final plans and specifications. These documents are used by the owner in programming future action and by the agency to evaluate probable compliance with statutes and regulations. The preliminary reports and plans shall broadly describe existing problems, consider methods for alternate solutions including site and/or facility relocation estimate capital and annual costs and outline steps for further project implementation including approval by regulatory agencies. No approval for construction can be issued until final, detailed plans and specifications have been submitted to the agency and found to be satisfactory.

(5) Engineering Report. The engineering report assembles basic information, presents design criteria and assumptions, examines alternate projects with preliminary layouts and cost estimates, offers a conclusion with a proposed project for client consideration and outlines official actions and procedures to implement the project. The concept, including process description and sizing, factual data and controlling assumptions and considerations for the functional planning of secondary and operational containment facilities are presented for each process at the facility as well as the overall operation of the agrichemical facility as a whole system. These data form the continuing technical basis for detail design and preparation of construction plans and specifications. Architectural, structural, mechanical and electrical designs are usually excluded. Sketches may be desirable to aid in presentation of a project. Outline specifications of process units, special equipment, etc. are occasionally included.

(A) Engineering Report Content. It is urged that the following paragraphs be utilized as a guideline for the content of the project engineering report to be submitted to the agency for review and approval:

1. Letter of transmittal. A one (1)-page letter typed on design engineer's letterhead should be included in the submission of the report to the client;

2. Title page. Title of project, agrichemical facility name and address, name and address of firm preparing the report, seal and signature of the professional engineer in charge of project;

3. Table of contents shall include section headings, chapter headings and subheadings, maps, graphs, illustrations, exhibits, diagrams and appendices. Number all pages and cross-reference by page number;

4. Introduction. Purpose—reasons for the report and circumstances leading up to the report;

5. Existing conditions at the agrichemical facility and discussion about proposed expansions or modifications to the facility;

6. Technical information and design criteria—

A. Process facilities. The process by which bulk chemicals are received, unloaded and transferred within the facility should be discussed. The mixing, loading and unloading of spreading or spraying equipment should be discussed. Design and sizing of secondary and operational containment structures should be discussed. All cleaning of chemical handling equipment, spraying or spreading vehicles, nurse vehicles and containment areas should be discussed. Collection, storage and disposal of rinsates, process generated wastewaters and collected precipitation should be discussed. Collection, treatment and disposal of all domestic wastewater flows associated with the facility should be discussed; and

B. Process diagrams. A process configuration showing the interconnection of all pumps, piping and storage tanks associated with the operation of the agrichemical facility should be shown; and

7. Summary. Highlight very briefly what was found from the evaluation of the facility and what the proposed recommendations are for the facility—

A. Findings. Method of operation, estimation of the number of cropping programs for which agrichemical services will be provided, sources of wastewater, proposed disposal or treatment practices;

B. Conclusions. Project recommended to client for construction; and

C. Recommendations. Summarized, step-by-step actions for client to follow to implement conclusions and submission of the report to the agency for review and approval.

(6) Primary Containment for Bulk Agrichemicals. Containers and appurtenances used as the primary containment in the storage and handling of bulk agrichemicals shall be constructed, installed and maintained to prevent a discharge and shall be of materials and construction compatible with the specifications of the product stored.

(A) In the event of a discharge or accumulation of storm water in the secondary containment area storage containers subject to flotation shall be anchored or placed on a raised stand to prevent flotation of the container in the event of a discharge or accumulation of storm water in the secondary containment area. The anchoring devices used to secure the storage container as well as any support structure for the storage container shall not compromise the structural integrity of the containment area or the ability of the containment area to adequately contain liquids that have accumulated in the containment area.

(B) All containers and appurtenances shall be designed to handle all operating stresses, taking into account hydrostatic head, pressure buildup from pumps and compressors and any other mechanical stresses to which the containers and appurtenances may be subject to in the foreseeable course of operation.

(C) External sight gauges shall not be used with bulk pesticide storage containers.

(D) External sight gauges may be used for bulk liquid fertilizer containers, but the gauge shall have a lockable valve located between the sight gauge and the storage container so

Schedule JAM-5

that if the sight gauge is damaged, the contents of the storage container will not leak out.

(E) The main discharge valve from the storage container shall be lockable.

(F) All appurtenances shall be protected against damage from operating personnel and moving vehicles. All appurtenances shall be located within the secondary containment or operational containment area.

(G) Storage of bulk liquid pesticides or bulk liquid fertilizers in an underground storage tank as defined by 10 CSR 20-10.010 is prohibited. This prohibition does not apply to a water-tight catch basin used for the temporary collection of runoff or rinsate from transfer and loading areas.

(H) All filling of containers acting as the primary containment vessel shall be done in a manner that the individual handling the transfer hose has both feet on the floor of the containment structure or a working platform adjacent to the container. The transfer hose used in the filling process shall be securely connected to the storage container by appropriate plumbing connections.

(7) Secondary Containment for Bulk Agrichemicals. Secondary containment for nonmobile bulk pesticides and nonmobile bulk fertilizers shall be designed to contain any spilled product from the primary containers or rainfall from the operational containment area and secondary containment area for the amount of time required for proper cleanup and recovery.

(A) Nonmobile Bulk Liquid Pesticides.

1. The volume of the secondary containment area when not protected from precipitation shall have a minimum volume of one hundred twenty-five percent (125%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

2. The volume of the secondary containment when protected from precipitation shall have a minimum volume of one hundred ten percent (110%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

3. The secondary containment structure shall not have a discharge outlet or gravity drain through the wall or floor of the containment structure.

4. The walls and floors of the secondary containment structure for nonmobile bulk liquid pesticide containers shall be constructed of suitable material that is compatible with the specifications of the product being stored. The walls and floors shall be resistant to penetration by moisture and agrichemicals. The walls and floors shall be designed to support the gravity load of the storage containers and any hydrostatic loads that would result from a massive spill within the containment structure.

5. For concrete floors and walls, expansion joints shall be spaced to prevent cracks from forming. The joints shall be sealed with a material resistant to agrichemicals. Water stops shall be installed between the containment walls and floor.

6. A collection sump may be included in the secondary containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area. The secondary containment structure floor should be sloped to the collection sump to allow for removal of liquids accumulating in the containment area.

7. No piping shall be installed through the walls or floor of the secondary containment structure except for interconnecting more than one (1) bulk liquid pesticide containment structure to another having a common wall. All piping entering and leaving the secondary containment structure shall go up and over the containment walls.

8. Piping used for transferring full strength agrichemicals, process wastewaters and rinsates shall not be buried underground.

9. Secondary containment for bulk liquid pesticides and bulk liquid fertilizers shall be separated at a minimum with a common wall. There shall be no interconnection of piping through a common wall between a bulk liquid pesticide secondary containment structure and a bulk liquid fertilizer secondary containment structure.

10. Auxiliary tanks for storage of rinsate or precipitation collected in the secondary or operational containment area shall be located within a secondary containment structure.

(B) Nonmobile Bulk Liquid Fertilizer.

1. The volume of the secondary containment area when not protected from precipitation shall have a minimum volume of one hundred twenty-five percent (125%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

2. The volume of secondary containment area when protected from precipitation shall have a minimum volume of one hundred ten percent (110%) of the volume of the largest storage container located within the containment area plus the space occupied by any other tanks located within the containment area.

3. The secondary containment structure shall not have a discharge outlet or gravity drain through the wall or floor of the containment structure.

4. The walls and floors of the secondary containment area for nonmobile bulk liquid fertilizer containers shall be constructed of suitable material compatible with the specifications of the product being stored. The walls and floors shall be designed to support the gravity load of the storage tanks and the hydrostatic loads of a massive spill within the containment structure.

A. Floors and walls may be covered by a synthetic liner installed according to the manufacturer's written directions and repaired and maintained according to the manufacturer's recommendations. The liner shall have an in-place permeability of 1×10^{-7} cm/sec. or less. The liner material shall be compatible with the chemicals being stored and the liner shall be resistant to punctures, abrasion, cracking and weathering.

B. Floors and walls may be constructed of suitable soil so that the finished compacted permeability rate of the floor and berm walls shall be 1×10^{-7} cm/sec. or less.

C. Soils used in the construction of the walls and floors of the secondary containment structure may be treated with bentonite clay so that the finished compacted permeability rate of the floor and berm walls shall be 1×10^{-7} cm/sec. or less.

D. The inner and outer slope and floors of an earthen secondary containment structure should be protected against erosion (for example, top soil placed over the seal with sodding or seeding, a compacted layer of washed river gravel or riprap material of a suitable size). If the inner side slope and floors of the containment structure are seeded or sodded, a six inch (6")-layer of top soil shall be placed over the floor and side slope prior to seeding or sodding to prevent the roots of the cover material from penetrating the earthen liner. Long rooted grasses shall not be used for seeding the side slopes and floors. If gravel or riprap is used inside the containment structure, the depth of the gravel or riprap layer shall be at least six inches (6") in depth. Side slopes of the earthen containment structure should not be steeper than a three to one (3:1) ratio of horizontal to vertical. The top width of earthen walls should not be less than two and one-half feet (2 1/2').

E. Floors and walls may be constructed of concrete or steel provided the material is protected from corrosion or deterioration from the materials being stored.

5. For concrete floors and walls, expansion joints shall be spaced to prevent cracks from forming. The joints shall be sealed with a material resistant to agrichemicals. Water stops shall be installed between the containment walls and floor.

6. A collection sump may be included in the secondary containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area. The secondary containment structure floor should be sloped to the collection sump to allow for removal of liquids accumulating in the containment area.

7. No piping shall be installed through the walls or floor of the secondary containment structure except for interconnecting more than one (1) bulk liquid fertilizer containment structure to another and piping exempted in subsection (3)(D). All piping entering and leaving the secondary containment structure shall go up and over the containment walls.

8. Piping used for transferring full strength agrichemicals, process wastewaters and rinsates shall not be buried.

9. Auxiliary tanks to hold rinsate or precipitation collected in the secondary or operational containment area shall be located within a secondary containment area.

(C) Nonmobile Bulk Dry Fertilizer Storage.

1. Dry fertilizer shall be stored inside a sound structure to prevent contact with precipitation. All surface water runoff shall be diverted away from the storage structure.

2. All unloading, loading, mixing and handling of dry bulk fertilizers should be done on an operational containment area.

3. Pesticide impregnation of dry fertilizer shall take place within an operational containment area adequate in size to hold the volume of pesticides used and impregnation equipment.

4. Unloading of bulk dry fertilizers may be satisfied by individual catchment basins.

5. Daily cleanup of the dry fertilizer loading, unloading, mixing and handling areas shall take place.

6. Whenever feasible, dry fertilizer spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

7. The floors of the bulk dry fertilizer storage area shall be paved with concrete or other approved materials that will prevent the downward movement of fertilizer materials and moisture through the floor. For concrete floors and walls, expansion joints shall be placed on a close enough spacing to prevent cracks from forming. The expansion joints shall be sealed with a material resistant to agrichemicals. Cracks that occur in the floors and walls shall be sealed to prevent the downward or lateral movement of fertilizer materials and moisture.

(D) Nonmobile Bulk Dry Pesticide Storage.

1. Dry pesticides shall be stored inside a sound structure to prevent contact with precipitation. All surface water runoff shall be diverted away from the storage structure.

2. All loading, mixing and handling of bulk dry pesticides should be done on an operational containment area.

3. Unloading of bulk dry pesticides may be satisfied by individual catchment basins.

4. Daily cleanup of the bulk dry pesticide loading, unloading, mixing and handling areas shall take place.

5. Whenever feasible, bulk dry pesticide spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

6. The floors of the bulk dry pesticide storage area shall be paved with concrete or other approved materials that will prevent the downward movement of pesticide materials and moisture through the floor. For concrete floors and walls, expansion joints shall be placed on a close enough spacing to prevent cracks from forming. The expansion joints shall be sealed with a material resistant to agrichemicals. Cracks that occur in the floors and walls shall be sealed to prevent the downward or lateral movement of pesticide materials and moisture.

(8) The operational containment area for bulk liquid pesticides and bulk liquid fertilizers shall be designed to contain any product discharged or collected precipitation for the amount of time required for proper cleanup and recovery.

(A) Wherever feasible, application equipment should be rinsed in the field to minimize containment and disposal requirements at the operational containment area.

(B) Precipitation should be diverted away from the operational containment area.

(C) The volume of the operational containment area shall be one hundred ten percent (110%) of the volume of the largest application vehicle that will be loaded or unloaded in the operational containment area. This volume may be achieved through the use of above ground tank(s) located within the secondary containment area connected to an automatic sump pump in the operational containment area.

(D) A sediment trap and sump may be designed in the operational containment area. The structure shall not be more than two feet (2') deep or hold more than one hundred fifty (150) gallons of liquid. The sump shall be constructed of materials that resist penetration by moisture and agrichemicals. The connection point between the operational containment area floor and the sump shall be sealed to prevent leakage of liquids from the containment area.

(E) Unloading containment may be satisfied by the operational containment area or with individual catchment basins or portable pans/containers. The individual basins or portable containers shall be placed to catch or recover spillage and leakage from transfer connections and pumps.

(F) Bulk repackaging containment of agrichemicals may be satisfied by the operational containment area.

(9) The operational containment area for bulk dry pesticides and bulk dry fertilizers. The operational containment area for bulk dry pesticides and bulk dry fertilizers shall be sized and designed to contain any spillage or leakage of dry materials that occurs from the loading and unloading of hauling or spreading equipment and from the mixing and blending equipment or precipitation that comes in contact with the operational containment area for the amount of time required for proper cleanup and recovery.

(A) Wherever feasible, spreading equipment should be cleaned in the field to minimize containment and disposal requirements at the operational containment area.

(B) Precipitation should be diverted away from the operational containment area.

(C) Unloading containment may be satisfied by the operational containment area or with individual catchment basins or portable pans/containers. The individual basins or portable containers shall be placed to catch or recover spillage and leakage from transfer connections and conveyors.

(10) Connection to Water Supplies. An air gap separation or reduced pressure principle backflow prevention assembly shall be installed in the water supply line that serves an agrichemical facility. The air gap or backflow prevention assembly shall be constructed, installed

Schedule JAM-5

and inspected in accordance with 10 CSR 60-11.010 Prevention of Backflow.

(11) Protection from Flooding. All agrichemical facilities shall be located so that the agrichemicals being stored are protected from a one hundred (100)-year flood event.

(12) Operation and Management of Agrichemical Facilities. Bulk agrichemicals shall be stored, handled, transported, loaded and unloaded in a manner to prevent discharge that may result in unreasonable adverse affects to humans or the environment. All applicable hazards of the pesticide shall be considered in the handling and loading practices to ensure proper protection of facility personnel and the environment.

(A) Discharges occurring to the secondary containment and operational containment area shall be recovered promptly. All waste and wastewater associated with the recovery process shall be disposed of in accordance with the permit for the facility and the product labeling.

(B) Precipitation collected in the secondary containment and operational containment area shall be disposed of in accordance with the permit for the facility.

(C) Field application of rinsate and collected precipitation is acceptable and recommended.

(D) Appropriate security measures at the agrichemical facility, such as lighting or security fencing to discourage ready access by unauthorized personnel to the facility when unattended, are encouraged.

(E) Agrichemical rinsates or collected precipitation shall not be disposed through storm sewers, sanitary sewer systems or waters of the state without an approved permit.

(F) Prior to repackaging or refilling bulk containers, the containers must be thoroughly cleaned and inspected except when a dedicated pesticide container is refilled and the tamper indicator is otherwise intact.

(13) Emergency and Discharge Response Plan. The operator of a bulk agrichemical facility shall prepare a written emergency and discharge response plan for the storage facility. The plan shall comply with Superfund Amendments and Reauthorization Act of 1986 (SARA) Title III requirements.

(14) Plans.

(A) General. All plans for secondary containment structures at agrichemical facilities shall bear the name of the agrichemical facility and shall show the scale in feet, a graphic scale, the north point, data and the name of the engineer, certificate number and imprint of his/her registration seal. The plans shall be clear and legible. They shall be drawn to a scale which will permit all necessary information to be plainly shown. The size of the plans generally should not be larger than thirty inches by forty-two inches (30" × 42") (76 cm × 107 cm). Datum used should be indicated. Locations and logs of test borings and when made shall be shown on the plans. Blueprints shall not be submitted. Detail plans shall consist of plan views, elevations, sections and supplementary views which, together with the specifications and general layouts, provide the working information for the contract and construction of the containment facilities. Include dimensions and relative elevations of structures, the location and outline form of equipment, storage tanks, location and size of piping and ground elevations.

(B) Plans of Agrichemical Facilities.

1. Location plan. A plan shall be submitted showing the location of the agrichemical facility in relation to streams, roads, water supply systems, property lines and any dwellings or structures not owned by the agrichemical facility in the immediate area of the facility.

2. General layout. Layouts of the proposed agrichemical containment facility shall be submitted showing topography of the site, size and location of storage tanks and containment structures, schematic flow diagram showing the flow through the various agrichemical mixing and handling systems, piping including any arrangements for bypassing individual systems, agrichemical handled and direction of flow through pipes, pumps and valves used for handling agrichemicals, storage areas for waste materials that cannot be reused (mud and sediment from sumps, dry fertilizer and pesticide materials accumulated during clean up processes, etc.), any test borings showing soil and rock elevations and composition at the proposed site and information showing existing groundwater elevations in relation to proposed liner installation and containment area floors shall be provided.

3. Detail plans. Unless otherwise covered by the specifications or engineer's report, detail plans shall show location, dimensions and elevations of all existing and proposed facilities; elevations of high and low groundwater level; size, pertinent features and operating capacity of all pumps, tanks, containment areas and other mechanical devices associated with the operation of the agrichemical facility and adequate description of any other features pertinent to the design and operation of the agrichemical containment facility.

(15) Specifications. Complete technical specifications for the construction of the agrichemical containment facility shall accompany the plans. The specifications accompanying construction drawings shall include, but not be limited to, all construction information not shown on the drawings which is necessary to inform the builder in detail of the design requirements as to the quality of materials and workmanship and fabrication of the project and type, size, strength, operating characteristics and rating of equipment; the complete requirements for all mechanical and electrical equipment, including machinery, valves, piping and jointing of pipe; electrical apparatus, wiring and instrumentation; operating tools; construction materials; special construction materials such as clay, sand, concrete or steel; miscellaneous appurtenances; instructions for testing materials and equipment as necessary to meet design standards and performance tests for the completed works and component units. It is suggested that these performance tests be conducted at the design conditions for the operation of the agrichemical facility whenever practical.

(16) Modifications During Construction. Any deviations or changes from the approved plans or specifications affecting capacity or operation of the agrichemical facility shall be noted on a set of as-built plans clearly showing the alternations. The as-built plans shall be submitted to the department at the completion of the project along with an application for issuance of an operating permit for the facility.

AUTHORITY: sections 644.026, RSMo Supp. 1990 and 644.036, RSMo 1986. Original rule filed July 15, 1991, effective Jan. 13, 1992.*

**Original authority: 644.026, RSMo 1972, amended 1973, 1987, 1993 and 644.036, RSMo 1972, amended 1973.*