The California State University

Office of the Chancellor

Utilities Infrastructure Master Plan Guideline for CSU Campuses

Rev. 08/18/05

Acknowledgement

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1.0 INTRODUCTION

1.1 Purpose

This guideline has been prepared for the California State University (CSU), Office of the Chancellor, to assist campuses in the planning and development of campus utilities and infrastructure master plan. It is recognized and advocated in this document that utilities and infrastructure plans are the next and immediate logical extensions of the campus master plans which are periodically developed and updated. As such, the document outlines the objectives, reasoning, and general methodology for developing the same as coordinated companion documents to the campus master plans. To assist engineering firms or engineering teams who may be retained to develop and update such plans, the document presents discussion of key steps needed, factors to consider and evaluate, and suggested formats for collection and presentation of information. This document and suggested guidelines should assist the campuses to prepare better for building growth and plan ahead for the budgeting, design and development of infrastructure projects. As a result, future campus building growth at each campus can be accommodated cost effectively.

1.2 Current Practice

Utilities infrastructure and central plant facilities are developed and expanded on campuses in a variety of ways. Some campuses have utilities infrastructure master plans fully developed along the lines described in this Guideline. Others have none at all or have very limited versions of plans, which cover only some of the utilities.

This non-standardized practice extends to project planning and funding. The CSU major capital project funding for utilities and central plant development varies widely. In some cases, there are discrete major capital projects exclusively defined as utilities infrastructure and central plant projects. These often flow out of well-developed infrastructure master plans. In other cases, the Feasibility Studies for new buildings include assessments of only a limited number of infrastructure components, such as the central heating and cooling plant. The problem with the latter approach is that there is little systematic assessment of available capacities of campus-wide utilities and central plant facilities. This leads to an implied assumption that centralized utilities and central plants have adequate capacities to serve new buildings. This, in turn, can lead to a crisis response when actual operation reveals that centralized utilities and central plants are loaded beyond their capacities.

Even when a new building Feasibility Study includes budget and scope for a central chiller or boiler, it is often included merely for a size and type of equipment to satisfy its specific loads. This usually is not in the best interests of the campus. For a simplified example, when a central chiller plant has limited physical space and expands in increments of 1,200 ton chillers, a new building calling for a 400-ton chiller presents a difficult situation. Neither a 400-ton chiller is desirable, nor is there budget allocated for the proper 1,200-ton chiller.

Lessons learned from historical practices, as illustrated in the fictitious examples discussed above, demonstrate the need for an improved, systematic, and methodical approach for planning, budgeting, and implementing campus-wide utilities infrastructure and central plant facilities.

1.3 Utilities Infrastructure Master Plan Reasons and Objectives

1.3.1 Reasons for Utilities Infrastructure Master Plans

The reasons for developing a utilities infrastructure master plan for each campus can be distilled to the following points:

a. To avoid the sense that campus-wide utilities and central plant facilities have “infinite capacity”

b. To develop a “global” highest efficiency campus utilities and central plant development plan to support FTE growth and programs vs. a short-sighted plan designed to support just the building

c. To replace or upgrade as appropriate aging utilities and infrastructure systems before they result in catastrophic failures and unplanned campus outages

d. To justify major capital project funding for utilities infrastructure and central plant projects

e. To coordinate utilities infrastructure and central plant development over time

f. To procure a comprehensive plan that is documented and supported by studies that can be easily updated as campus planning changes

g. To procure a plan that helps Physical Plant respond to queries about the impacts of future expansion

1.3.2 Objectives

A utilities and infrastructure master plan must serve the following primary objectives:

a. It must be comprehensive and cover all applicable utilities and must advocate an implementation plan that is timely to serve the needs of the buildings planned for the future per the latest campus master plan. Therefore it follows that it must be directly linked to the latest adopted master plan.

b. It must embody sizing, design, and development concepts that are cost effective over the life-cycle while integrating well with the existing infrastructure.

c. It must be based on a careful consideration of uncertainties associated with future building growth and consider a phased development approach where it makes sense.

d. Its implementation plan must be such that it has minimal interruptions to existing campus operations.

e. It must recognize campus specific constraints as well as utility provider characteristics to fit well within the scope of overall campus operability.

f. It must remain responsive to the CSU systemwide energy and utility policies as set forth by the CSU Chancellor’s Office.

2.0 DEVELOPING A UTILITIES INFRASTRUCTURE MASTER PLAN

A utilities infrastructure master plan is a systematic approach towards determining the appropriate means for expanding and upgrading a campus utilities infrastructure and central plant facilities. Such plans are best developed by retaining the services of engineering firms or teams that have both knowledge of campus systems and experience in the study and design of utilities, central plant facilities and campus infrastructure systems.

Any given campus has a large number of utilities and infrastructure systems, each offering its own unique complexities and challenges. Finding extensive funding for studying all aspects thoroughly and comprehensively is always a challenge with limited funding. The campus and the engineering firms or teams retained to provide such planning services are therefore encouraged to review these guidelines and determine the level of effort warranted in each case prior to establishing a detailed scope for services and budget estimates for such studies. Specifically, it is recommended to determine and mutually agree on the extent to which the rigorous methodology presented herein applies for each given situation. It is possible that on a case by case basis and for certain utilities, a simplified approach or a limited study may be sufficient. This is especially true if the campus is already well prepared or the long term changes being contemplated by the campus master plan are limited in scope.

Figure 1 illustrates the basic utilities and infrastructure planning process. Chapter 3 of this guideline presents a general format of deliverables to be expected as a product of this planning process.

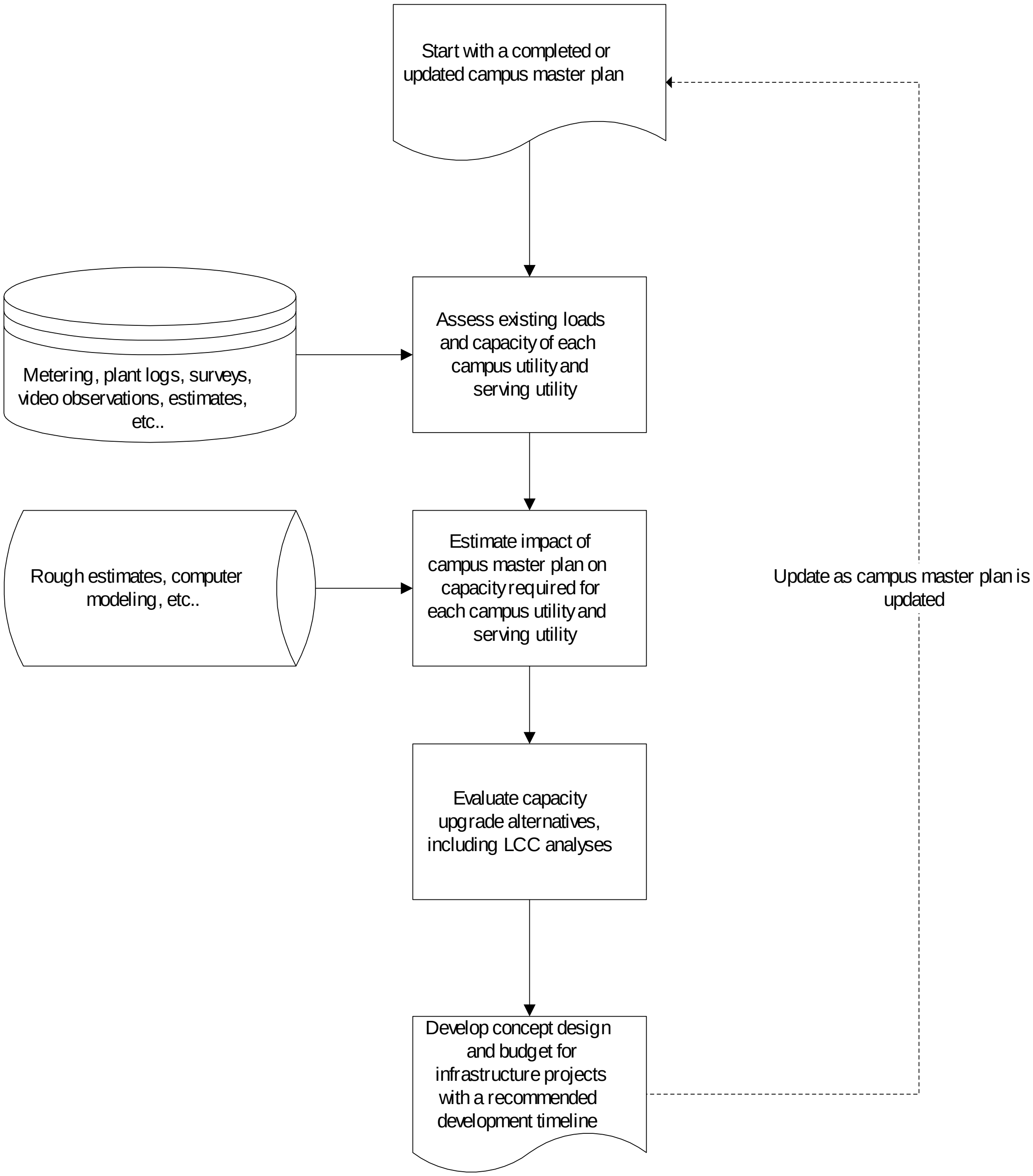

Figure 1 - The Utilities Infrastructure Plan Development Process

2.1 Utilities and Infrastructure Systems Covered

Depending on the applicability at each specific campus, the following campus-wide utilities and central plant facilities should be covered in a utilities infrastructure master plan:

a. Central Cooling System
b. Central Heating System
c. Domestic Cold Water
d. Domestic Hot Water (DHW) Distribution
e. Fire Water
f. Irrigation
g. Sewer
h. Storm Drain
i. Natural Gas
j. Electrical Power Supply and Distribution Systems
k. Standby/emergency Generation Systems
l. Cogeneration and distributed generation
m. Photovoltaics and other renewable energy resources
n. Energy Management System (EMS)
o. Data/Telecommunications
p. Fire Alarm System
q. Utilities Tunnel Extensions

2.2 Coordination of Utilities Master Plan with the Campus Master Plan

Each campus has a campus master plan that is developed articulating future building additions, deletions and renovations. This plan is used to intelligently develop each campus as a whole coordinated entity in response to accommodating future programmatic needs. Specifically, this development is based on a careful consideration of many factors including:

a. Expected growth in FTE students and programs ***(loads)***
b. Types of programs and buildings envisioned for each campus ***(scope)***
c. Age of existing buildings and feasibility of renovation versus replacement (***age***)
d. Major capital funding for new and renovated buildings required to support program expansion and FTE growth ***(cost estimates and budgets)***
e. Timeline for implementing new buildings to support program expansion and FTE growth ***(schedule)***

Similarly, the campus-wide utilities and infrastructure systems need to be carefully developed and expanded in a systematic and coordinated manner to support the campus master plan. This development should be based on consideration of several key factors such as:

a. Types of utilities and central plant facilities that will be the most cost effective in serving each campus ***(scope)***

b. Demands placed on those utilities and central plant facilities due to FTE growth and program expansion ***(loads)***

c. Age of existing utilities and infrastructure systems ***(age)***

d. Major capital funding for new, upgraded, and expanded utilities and central plant facilities required to support program expansion and FTE growth ***(cost estimates and budgets)***

e. Timeline for implementing new, upgraded, and expanded utilities and central plant facilities new buildings to support program expansion and FTE growth ***(schedule)***

Since the two master plans are inherently linked, both in their campus-wide scope and in their need to support FTE growth and program expansion, it naturally follows that they should be well coordinated. The campus master plan establishes the basic FTE growth and program expansion and is developed first. Once the master plan is adopted, the utilities and infrastructure planning effort should be commenced immediately. Furthermore, the campus master plan and the utilities master plan should also be updated concurrently. In this way, the two campus-wide master plans are linked, and the projects that flow out of them are intelligently coordinated, budgeted, and scheduled.

2.3 Assessment of Existing Utilities, Loads and Capacities

The first step in developing a utilities infrastructure master plan is to identify and assess the condition and capacity of the existing utilities, and infrastructure, including central plant system(s). This assessment must be done in relation to existing buildings and loads that are already served by the utilities. This includes assessment of the following:

a. Number, location, type, and size of existing buildings

b. Capacities and location of all existing utilities and central plant facilities

c. Condition (remaining useful life) of all existing utilities and central plant facilities

d. Estimation of remaining spare capacity of each utility

e. Existing loads imposed on the utilities and central plant facilities, and the load locations

f. Research related to known problems, if any, as experienced by the campus

g. Last available updates or studies that may be available related to the utilities

As-built drawings, other documents, physical assessments on site, and interviews with campus physical plant personnel are all useful ways in gathering this information. Research required for an accurate assessment should not be limited to review of existing documents, records and discussions. Therefore, on site surveys, cross check of information through analysis, sample metering, spot measurements, videotaping, and such other tools as may be applicable to the specific utility that is being evaluated should also be considered.

Depending on the situation, determination of existing loads could require some analytical effort, which might include computer modeling (pipe flow analysis), calculations, and estimations from industry guidelines and standard practices. It also might entail some empirical evidence from utilities and central plant operational history. The basis for use of factors and assumptions in computer models should reflect conditions unique to the campus.

The utilities infrastructure engineer has to use its best judgment in determining the optimal level of effort associated with characterizing the condition of existing utilities. The level of effort must be commensurate with the accuracy needed for a given situation, and must be mutually discussed and agreed to between the campus and the utilities and infrastructure engineer prior to the commencement of the planning process.

2.4 Estimation of Growth Impact of the Utilities

2.4.1 General Approach

The second step in the planning process deals with evaluating the impact of each master plan building addition, deletion or renovation on each of the affected utilities. Campus growth information is derived directly from the campus master plan. Diversity[1] in building usage and loads will also need to be considered based on historical operating experience at the campus as well as planned future usage of campus buildings. Based on this growth information and diversity estimates, the utilities and infrastructure master plan must identify (a) which buildings will be connected to which utilities, (b) estimate the load impact imposed by the building on the affected utility, and (c) assess composite load impact on the central plant systems.

Some future buildings might be small and remotely located on campus, and thereby would not be cost effective for connection to the existing central utility system on campus. Such choices will need to be coordinated and discussed with the campus prior to finalizing the utilities and infrastructure master plan. Additionally, choices made in the planning process need to be well documented for the benefit of future campus management personnel as well as A&E teams that may be involved in future building design efforts.

The Tables 1 and 2 below give a suggested format for compiling both a check list and summary of impact projections related to utility areas that may be affected by each building.

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[1] Diversity for a given central utility is a ratio, computed as the highest aggregate demand (system peak) collectively imposed on the utility by the buildings served, divided by the summation of individual building peak demands, each of which may occur at a time that does not necessarily coincide with the time of system peak. Under this definition, if all buildings exhibit their respective peak loads at the same instant, the diversity factor is unity (1) for that utility.

Table 1 - Summary of Master Plan Impact on Utilities

Matrix Identifying Potential Areas of Impact of Master Plan on Campus Utilities Infrastructure

Campus: Master Plan Last Updated (mm-yy): Master Plant Architect::

Date This Status Prepared/Updated: Current Building GSF: Proposed Building GSF Based on Master Plan:

					Indictate a Check Mark to Designate if the Proposed Building Impacts the Following Utilities and Infrastructure Systems																
Year of Proposed Startup	Master Plan Building	Building GSF	State [2]	Non-State [3]	Central Cooling System	Central Heating System	Domestic Cold Water	Domestic Hot Water (DHW) Distribution	Fire Water	Irrigation	Sewer	Storm Drain	Natural Gas	Electrical Power Supply and Distribution Systems	Standby/emergency Generation Systems	Cogeneration and distributed generation	Photovoltaics and other renewable energy resources	Energy Management System (EMS)	Data/Telecommunications	Fire Alarm System	Utilities Tunnel Extensions
2005																					
2006																					
2007																					
2008																					
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2031																					
2032																					
2033																					
2034																					
2035																					
Aggregate GSF of Buildings Impacting Each Utility [1]																					

[1] Indicate for each utility approximate GSF of buildings that could impact load on the utility. Indicate a "NA" if area is not applicable.
[2] Identify state funded buildings with a check mark in this column
[3] Identify non state funded buildngs with a check mark in this column

Table 2 - Summary of Load Impact Assessment

Name of the Utility: ____________________________________

# of Years into the Future [6]	Building Name	Building Area (GSF)	Estimated Building Peak Demand (Units X)	Diversity Factor [1]	Demand on Central Utilities/Plant Systems [2] (Units X)	Estimated Diversified Peak Demand Averaged Over Campus Applicable Peak Window [3] (Units X)	Estimated Cumulative Peak Demand (Diversified) [4] (Units X)	Peak Capacity Deficit [5] (Units X)	Description or Comments
1									
2									
3									
4									
5									
6									
7									
8									
9									
10									

[1] See Diversity definition in Section 2.4, Page 7
[2] Individual building peak demand times diversity factor equals the demand on the central utilties
[3] The peak window varies by campus and is generally dependent upon the serving utility rate schedules
[4] Represents the cumulative impact of future buildings on the central utilities
[5] Cumulative demand less the current available capacity in a given year represents deficit, if any
[6] # of future years considered issame as what is used in the campus master plan

2.4.2 Level of Effort

To determine the existing capacity of the existing utilities distribution systems, and to test the impact of future loads on those systems, some form of analysis must be conducted. The utilities and infrastructure engineer, in consultation with the campus, must use its best engineering judgment on the level of effort associated with making estimates of load impacts. The range of analyses may include anywhere from engineering judgment and preliminary estimates to detailed computer modeling of systems being evaluated.

For example, hydronic systems, such as chilled water (CHW) and heating hot water (HHW) distribution systems lend themselves to a number of computer modeling programs that model and identify pipe segments that reach capacity and require expansion as loads increase.

For central plant systems, it is important to realize that delta T (the temperature difference between circulated supply water and return water) is a critical parameter in determining the loads upon, and the capacity of, CHW and HHW distribution systems. This is so critical, that a feasible CHW distribution system capacity increase project may entail building cooling coil replacements to increase CHW delta T.

For electric power distribution systems, it is important to evaluate conductor capacity at various loads and duct bank configurations to determine the effects of duct bank heating. As circuit loads increase, conductor ampacity can actually decrease.

There are also special computer modeling programs specifically tailored to domestic water and fire water distribution systems.

Hydraulic computer models are also used in sewer system analysis. Electrical distribution system computer programs model electrical loads, conductor capacity and voltage drop to determine electrical distribution system capacities. To strike a reasonable balance between costs of developing the plan and accuracy of estimates required, it is recommended that the campus and the utilities and infrastructure engineer discuss and mutually agree on the level of effort that is prudent for each given situation prior to proceeding with the detailed planning process.

2.4.3 Consideration of State-Funded and Non-State-Funded Facilities

State-funded facilities on campuses are obvious candidates for connection to campus-wide utilities and central plants; provided they can be cost-effectively connected (i.e. they are sufficiently sized and are not remotely located).

Non-State-funded facilities involve an additional consideration; that is, how to meter and recharge them for utilities if the are centrally connected. Because of this, many non-State-funded facilities have their own electric, gas, water, and sewer services, which are separately metered and directly billed from the serving utility. HVAC is often individually provided as well.

However, some non-State-funded facilities are connected into campus-wide utilities and central plants, often because these centralized systems tend to be more efficient and cost effective. Sub-metering and recharging needs to be addressed in these instances.

State capital funds cannot be used for making connections to or extending an existing line or pipe to serve non-state buildings. However, the CSU Policy recognizes that it is practical and reasonable to size main infrastructure systems (e.g., chilled water distribution mains, campus water mains, hot water distribution mains, campus main electrical substation, etc.) so that they have adequate capacity to accommodate loads associated with all campus buildings.

There is no general "right answer" as to whether non-State-funded facilities should be centrally or separately connected. Rather, the different implications involving non-State funded facilities must be addressed in the utilities infrastructure master plan. The utilities and infrastructure engineer must consult with the campus on these issues prior to developing the overall plan.

2.5 Evaluation of Alternatives, and Life Cycle Costs Analyses

The third step in the evaluation process involves a careful formulation and evaluation of the alternatives. The utilities and infrastructure engineer must carefully consider possible and competing alternatives available to the campus for providing the needed utility capacity for future buildings. This evaluation should include all utilities needed for future buildings. The alternative evaluation becomes particularly important when a building is remotely situated or when several buildings while grouped together could potentially offer prospects for satellite plants or infrastructure systems. Where applicable, there could also be alternatives developed for phasing the overall capacity addition in discrete increments. The engineer must approach such alternatives with an open mind, and discuss and evolve practical and reasonable alternatives applicable for the given situation in consultation with the campus. Where appropriate, it is not unreasonable to consider as many as three alternatives for a technical and economic evaluation. In some cases, there many not be a need to examine many alternatives because the solution is quite obvious. It is therefore recommended that each case be evaluated based on its own unique characteristics and in consultation with the campus, prior to conducting a detailed assessment. Alternative evaluation is certainly relevant for central plant development where campus heating and cooling can be accomplished in a variety of ways. It is particularly applicable in the early stages of campus central plant development, or in cases where most of the central plant is aged. It is at these times when the greatest opportunity exists for a feasible alternative to central plant development.

A life cycle cost analysis should be included in alternative analysis, and should entail first cost, replacement costs, energy costs, O&M costs, and regulatory costs (such as permitting),. To determine future costs on a present worth basis, discount factors customarily used for public projects should be used as part of the Life Cycle Cost analysis. It is likely that the alternative with the least Life Cycle Cost should be given serious consideration as the preferred alternative for development at the campus. A Microsoft Excel life cycle cost spreadsheet, including the values of many parameters, can be found at the California State

University Capital Planning, Design, and Construction website at:
http://www.calstate.edu/cpdc/AE

2.6 Formulation of Specific Infrastructure Projects

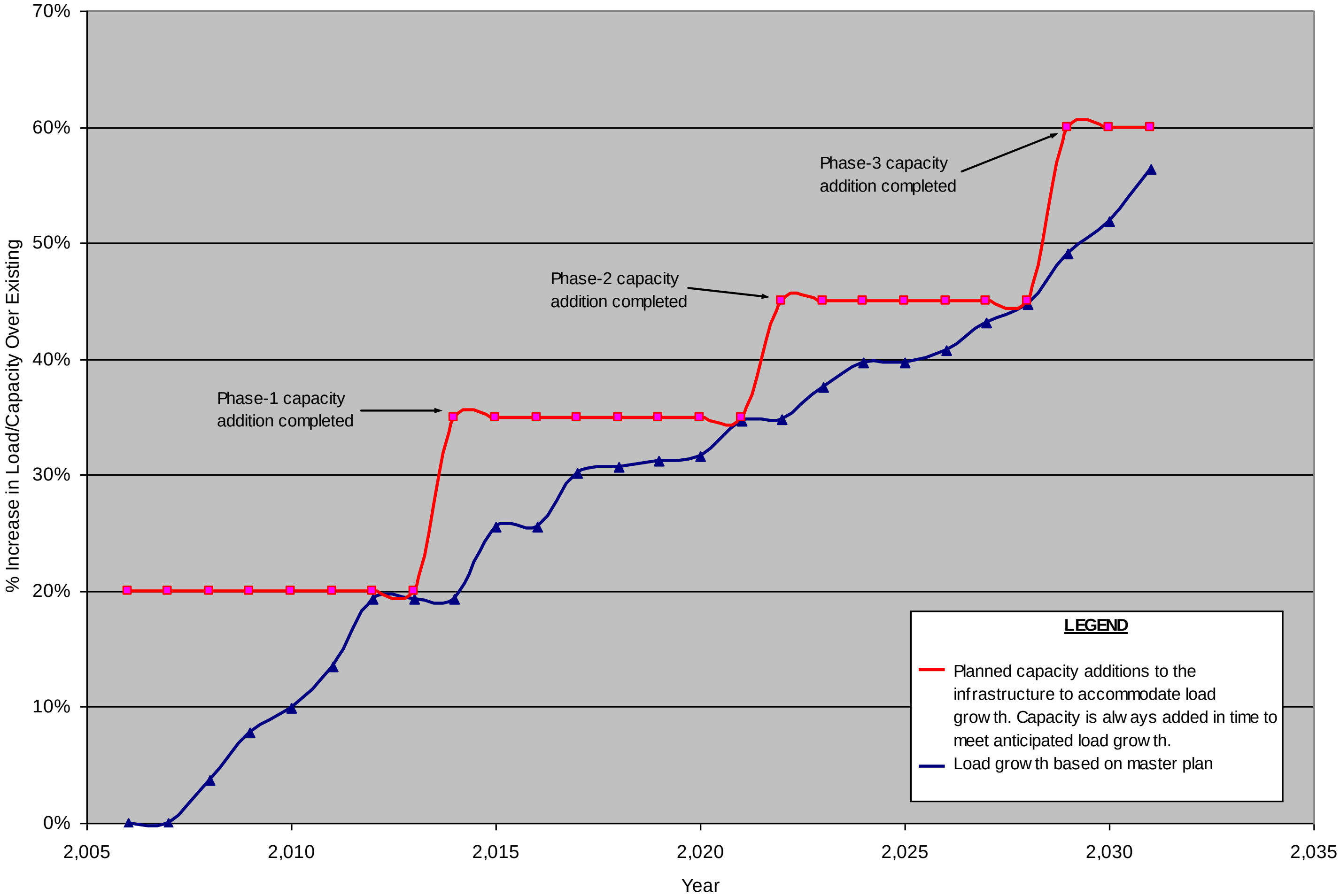
Once the growth impacts are understood and clearly quantified as a function of time, the fourth and final step involves formulation of specific utilities and infrastructure projects with a specific scope and development time line attached to each, while considering the following constraints. Figure 2 shows a sample illustration of a phased implementation of utilities upgrade. Table 4 shows a suggested format for the presentation of development timeline, while showing relationships with master plan building projects as well as utilities affected by each specific infrastructure project.

a. The realistic time frame for developing a capital outlay utilities and infrastructure project, starting from the time it is budgeted to the time it actually gets built could be a minimum of 3-5 years, depending on the size of the project. This lead time must be taken into consideration to ensure that the affected utility/infrastructure is ready and available in time for the planned building addition.

b. Campuses can not generally propose more than one capital outlay funding request in the same fiscal year. Therefore, any significant utility infrastructure project will have to be scheduled for funding when no other major capital outlay is proposed. Also, proposed infrastructure projects should include consideration of all applicable utilities.

c. To minimize cost and disruptions associated with construction, it maybe relevant to consolidate and merge various types of utility expansions into logically grouped utility and infrastructure projects so that repetitive work associated with excavations can be avoided, or trenching work and tunneling work can be consolidated where practical to accommodate several utilities under a common construction effort.

Figure 2 - Sample Illustration of Phased Implementation of Utility Upgrades[2]



[2] The number of phases shown here are for illustration only. Depending on the scope and complexity of the project, lead time associated with implementing each phase will vary by campus and by utility. Such items will need to be established as part of the utility and infrastructure development plan.

2.7 Updating the Utilities and Infrastructure Master Plan

Any time that the campus master plan is updated, the utilities and infrastructure master plan should also be updated as soon as the campus master plan draft is complete. Since a campus master plan update may be quite targeted or limited in its scope, the utilities infrastructure master plan can be similarly limited and targeted in its scope. Part of any utilities and infrastructure system update must include an assessment of remaining system capacities in each affected utility.

For example, perhaps the campus master plan update involves two future planned buildings in a localized area of the campus that will have stand-alone heating and cooling. In this case, updates to the plan regarding the central plant facilities would not be necessary. Other utilities intended to serve the two new buildings would be analyzed and updated only in that localized area of the campus and only to the magnitude of the loads imposed upon them.

In this way, the scope required to update the utilities and infrastructure master plan can be appropriately limited, but still targeted to what is necessary. And more importantly, the two campus master plan and the utilities and infrastructure master plan remain linked as living campus planning documents. The projects that flow out of them are intelligently coordinated, budgeted, and scheduled.

2.8 Maintaining Current Status of the Utilities and Infrastructure Plan

The campus is recommended to maintain a status matrix of its utilities and infrastructure systems at all times. This matrix will help maintain an accurate log of when a specific utility system was last upgraded, plans evaluated or updated, the A&E team responsible for updating the plan, and any comments relevant to the specific utility. It is further recommended that such a plan be reviewed in connection with a proposed building project to ensure that adequate provisions have been made to serve the building without overloading the utilities systems.

The suggested format for such a status matrix is presented below in Table 3 for use by the campus.

Table 3 - Current Status of Utilities Infrastructure Master Plan

Campus	
Master Plan Last Updated (mm-yy)	
Master Plant Architect	
Date This Status Prepared/Updated	
Current Building GSF	
Proposed Building GSF Based on Master Plan	

Type of Utility/Infrastructure	Date Installed [1]	Date Last Upgraded [1]	Plan Last Studied/Updated (mm-yy) [2]	Proposed Next Update (mm-yy) [3]	Comments on Adequacy of Capacity or Condition of System (Year)[4]	Utilities and Infrastructure Planner(s) Involved [5]
Central Cooling System						
Central Heating System						
Domestic Cold Water						
Domestic Hot Water (DHW) Distribution						
Fire Water						
Irrigation						
Sewer						
Storm Drain						
Natural Gas						
Electrical Power Supply and Distribution Systems						
Standby/emergency Generation Systems						
Cogeneration and distributed generation						
Photovoltaics and other renewable energy resources						
Energy Management System (EMS)						
Data/Telecommunications						
Fire Alarm System						
Utilities Tunnel Extensions						

[1] Indicate the approximate date when the system was installed or upgraded
[2] Indicate the approximate date when the specific utility/infrastructure was evaluated
[3] Indicate, plans if any, when the specific infrastructure is proposed to be reevaluated as part of the Infrastructure Master Plan
[4] Indicate briefly whether capacity is adequate, or if there are specific concerns related to existing age/condition. Refer to attachments as needed.
[5] List consultant(s) associated with evaluating the specific utility or entities involved in the last design update

Table-4 - Summary of Infrastructure Projects Development Timeline In Relation To Campus Master Plan Building Projects

					Highlight Utility and Infrastructure Systems Expanded by the Proposed Infrastructure Project																
Year of Proposed Funding Request	Master Plan Building OR Proposed Utility Infrastructure Projects (High Lighted)	Building GSF	State Funded [2]	Non State Funded [3]	Central Cooling System	Central Heating System	Domestic Cold Water	Domestic Hot Water (DHW) Distribution	Fire Water	Irrigation	Sewer	Storm Drain	Natural Gas	Electrical Power Supply and Distribution Systems	Standby/emergency Generation Systems	Cogeneration and distributed generation	Photovoltaics and other renewable energy resources	Energy Management System (EMS)	Data/Telecommunications	Fire Alarm System	Utilities Tunnel Extensions
2005																					
2006																					
2007																					
2008																					
2009	Infrastructure Project, 1 [1]																				
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2011																					
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2033																					
2034																					
2035																					

[1] Each proposed project is highlighted, showing specific utilities proposed to be upgraded under the scope of the project
[2] Projects are scheduled such that no infrastructure project and building projects are funded in the same year
[3] Identify non state funded buildngs with a check mark in this column

3.0 DELIVERABLES

3.1 General Requirements

Utilities infrastructure master plan should be a comprehensive road map on how to get there from here. The scope and implementation schedule of the recommended utilities upgrade projects should show exactly when the recommended utility systems are required to come on line to support FTE growth and program expansion. The utilities master plan should be used to properly plan, size and locate utility systems to avoid construction conflicts.

The scope of the recommended upgrades should be expressed in a detailed narrative describing each component for expanding and upgrading the utilities infrastructure and central plant. This narrative should be accompanied by conceptual design drawings, single line drawings, and campus maps overlaid by existing and future utilities systems.

The cost estimates of the recommended utilities upgrade projects should be itemized at least by utility system and major equipment, piping, electrical, etc. The itemization should be commensurate with the conceptual design level presented for the recommended projects.

Generally, the following deliverables should be provided with each utilities infrastructure master plan:

a. Hard copies of the draft Utilities Plan for comment and review by campus personnel

b. Hard copies and an electronic copy of the final Utilities Infrastructure Master Plan, with revisions incorporated from comments received

3.2 Recommended Details

Deliverables should comprise a document that presents:

a. Scope of the planned utility systems upgrade projects,

b. Project costs,

c. Projects implementation schedule,

d. Reasoning behind the overall plan, and

e. Confirmation that it conforms to the master plan schedule.

Specifically, the following details are suggested for inclusion.

Chapter text with:

a. Narrative descriptions of existing utilities and facilities

b. Reference to the specific master plan on which this plan is based

c. Summary status of existing utilities (See Table 3 of this document for a sample format)

d. Campus constraints and choices made relevant to the planning process

e. Impact of future growth on utilities and facilities (See Tables 1 and 2 of this document for a sample format)

f. Alternatives considered and those recommended

g. Recommended scope of major capital utilities infrastructure projects

h. Project development recommendations, including specific projects and development timeline to meet the master plan related capacity requirements. (See Table 4 for a suggested format for presentation of development timelines and interrelationships with the campus master plan)

i. Graphical representations that effectively demonstrate long term utility capacity in relation to the campus growth and demand (See Figure 2 of this document for a sample format of the same)

j. Cost estimates for recommended major capital utilities infrastructure projects

Drawings showing:

a. Existing campus plan and existing utilities layered thereupon in separate drawings

b. Future campus plan and existing and future utilities layered thereupon in separate drawings

c. Conceptual diagrams of central plant development

d. Implementation schedules identifying budgeting, design and construction phase schedule for recommended major capital utilities infrastructure projects

e. Matrix presentation of project budgeting time frames to confirm that the infrastructure projects do not overlap with master plan new building projects

f. Matrix presentation of infrastructure projects with the master plan building projects to confirm that the proposed development cycle meshes in a timely manner with the planned building development schedule

Supporting appendix materials:

a. Metering information

b. Survey of existing systems

c. Computer modeling outputs

d. Catalog cut sheets

e. Computer input and output data

f. Calculations

g. Life cycle cost spreadsheets