CHILLED WATER MASTER PLANNING & HYDRONIC MODELING

@ THE UNIVERSITY OF COLORADO BOULDER

Presented by

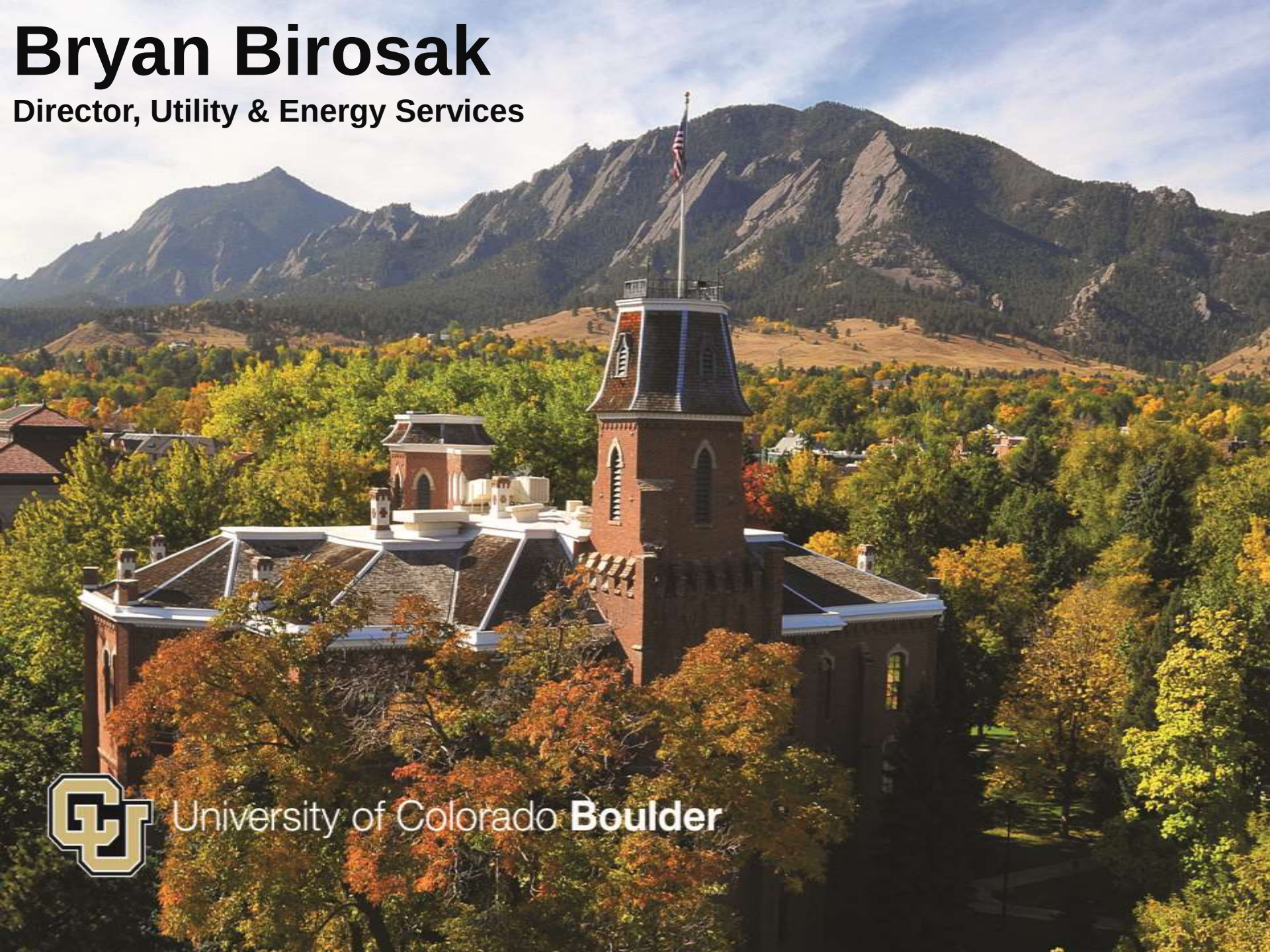
TREFZ ENGINEERING INCORPORATED

University of Colorado Boulder

STPCX LLC

Bryan Birosak

Director, Utility & Energy Services



Utility Master Plan

- By 2010, with the majority of the existing utility system infrastructure at the end of its useful life, along with significant growth in campus cooling requirements, and a commitment to reduce carbon, the University of Colorado began a series of studies to formulate a Utility Master Plan that would provide a balance between cost, carbon, and conservation.

- The growing cooling demand was a primary driver for the campus to approve the upgrades. This presentation will focus on the CU CHW Upgrades

CU Power House (WDEP)

CU Boulder CHW Infrastructure (1992 – Summer 2014)

- Three (3) Steam Absorption Chillers
- Combined total capacity of 3,200 tons with a 2,200 ton Peak Demand
- Located in the campus's original West District Energy Plant
- 1.75 Miles of CHW DIST in Tunnels
- 14 Buildings

Original Chillers

CHW System Master Plan

- As part of the Multi-Year Utility Infrastructure Improvements Project the campus cooling system was expanded to include newly renovated **Student Housing Facilities.**
- Existing **distributed chillers** at the end of their useful life were removed and connected to the central loop to optimize system performance and efficiencies.
- The “Big Dig” installed 5 miles of new direct buried CHW Distribution piping
- The new infrastructure provides a scalable and cost effect approach that provides a flexible roadmap for future growth and technology improvements

West District Energy Plant (WDEP)

New CHW Generation West District Energy Plant (WDEP)

- Two (2) new 1,625 ton variable flow Chillers
- 460V, Variable speed, Electric Driven Machines

New Chillers

New CHW Generation East District Energy Plant (EDEP)

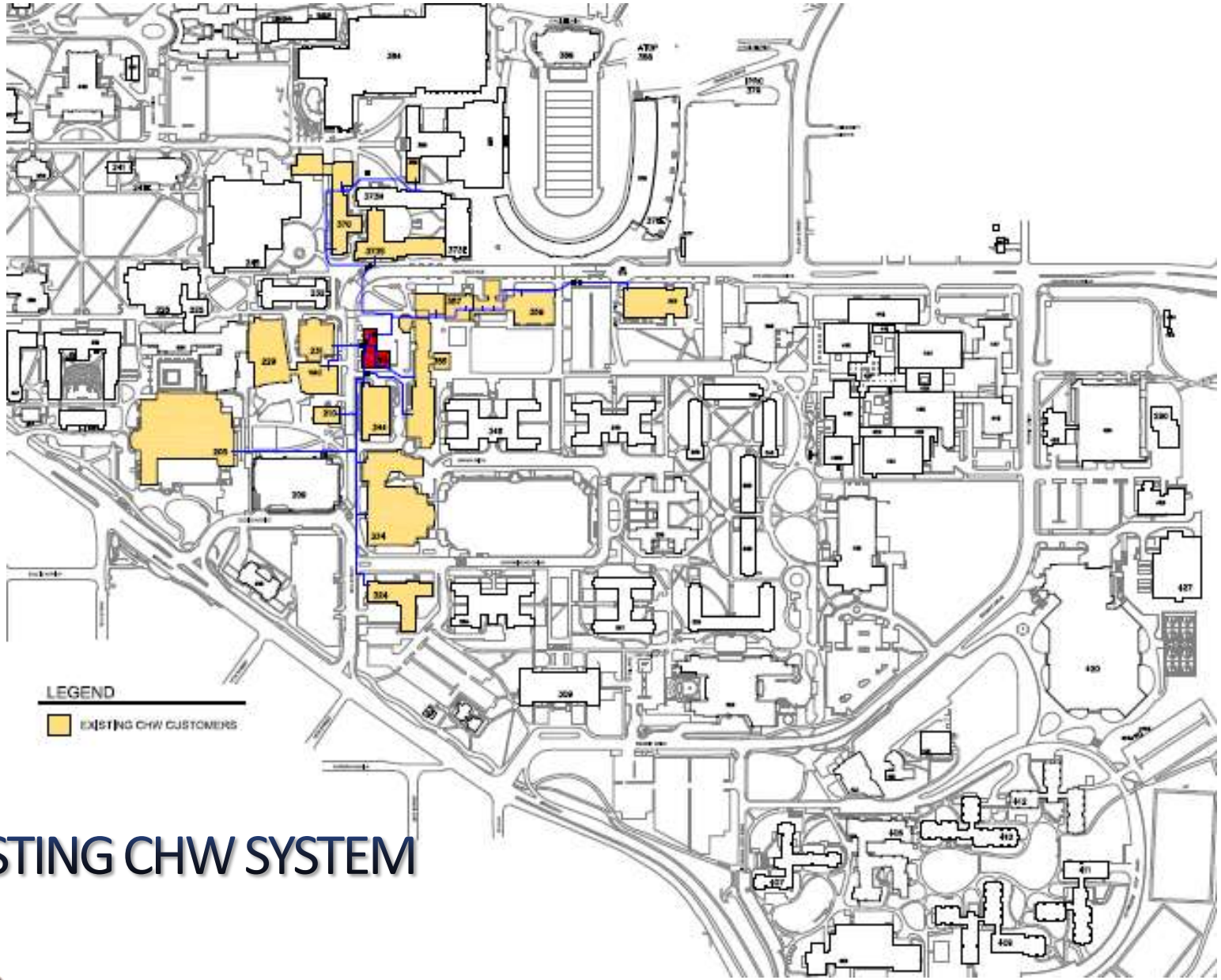
- Two (2) 1,650 ton Chillers
- 4160V Variable Speed Chillers
- Plant designed to accommodate an additional 3 chillers (5 total) to meet future campus growth and cooling demands.
- Design to house 2,000 ton Machines without building or piping upgrades

New Chillers

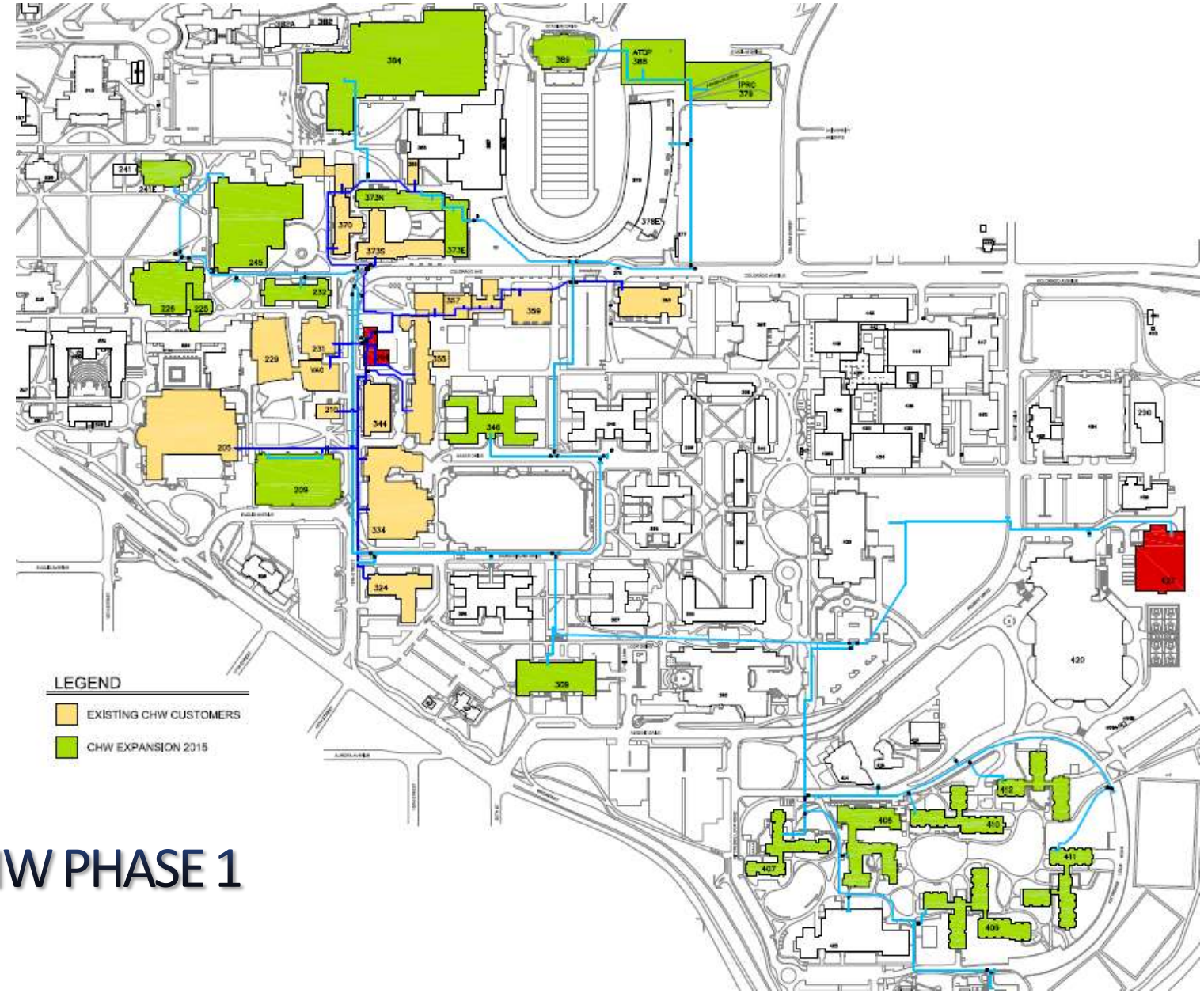
New CHW Distribution Infrastructure

- Distribution System Interconnects both District Energy Plants and one 1,000 ton Satellite Facility
- Designed to accommodate a wide range of existing campus cooling loads and the future loads without additional upgrades or long-term operational impacts.
- Added 5 miles of CHW Piping
- 20 New buildings connected to the loop. 34 Total Customers for 2015.
- DIST Capacity sized for 14,250 tons

New Chilled Water Lines

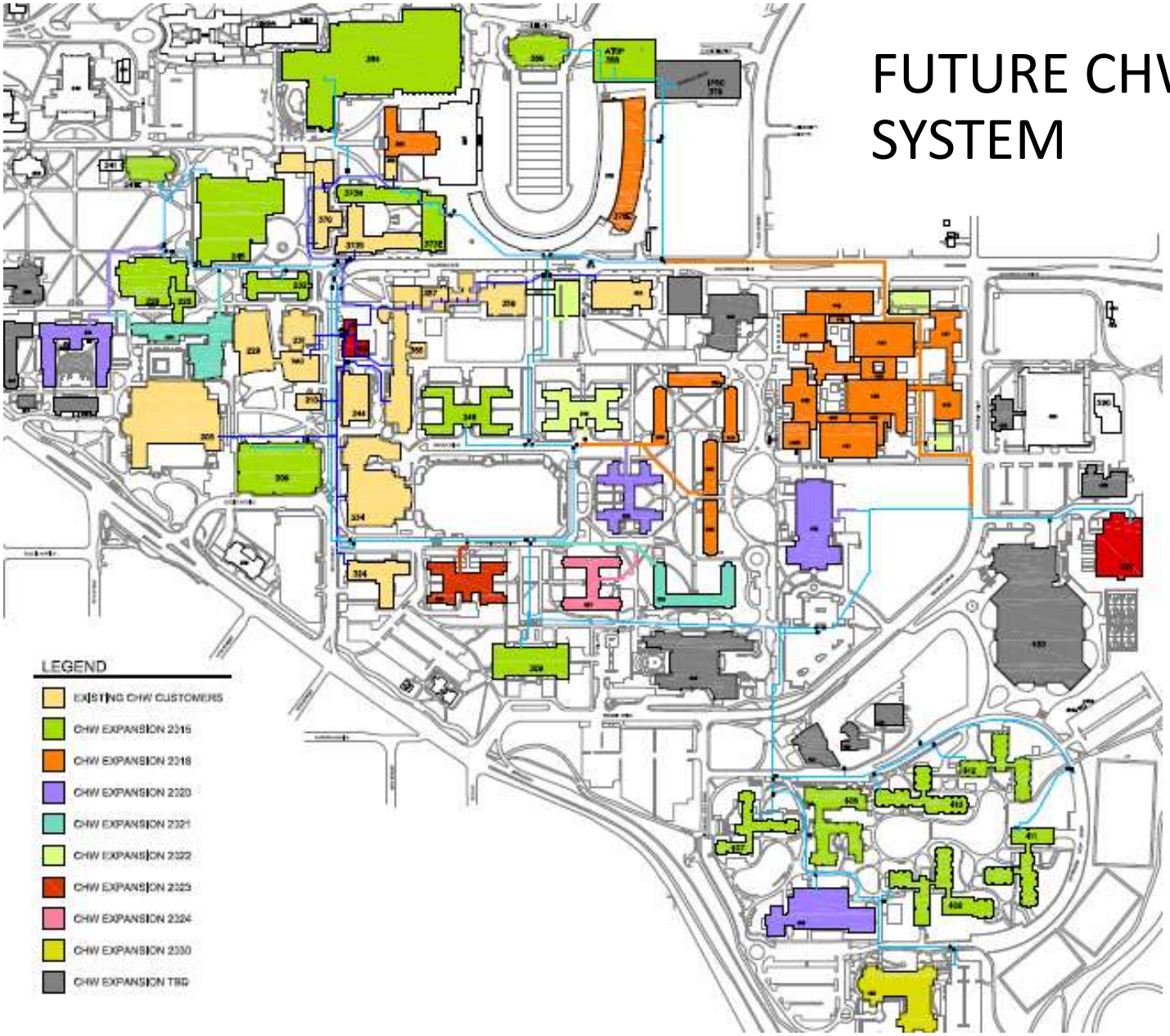


EXISTING CHW SYSTEM



CHW PHASE 1

FUTURE CHW SYSTEM



Jason Trefz

Project Manager & Mechanical Engineer

MASTER PLANNING AND HYDRONIC MODELING

- UNDERSTAND EXISTING SYSTEM OPERATIONS AND SYSTEM DYNAMICS
- IDENTIFY PROBLEMS AND ECONOMICAL SOLUTIONS
- PROJECT FUTURE INFRAS. REQUIREMENTS
- GROWTH PLAN FOR INFRAS. EXPANSION
- ANTICIPATE CHANGE AND PLAN FOR FUTURE GROWTH

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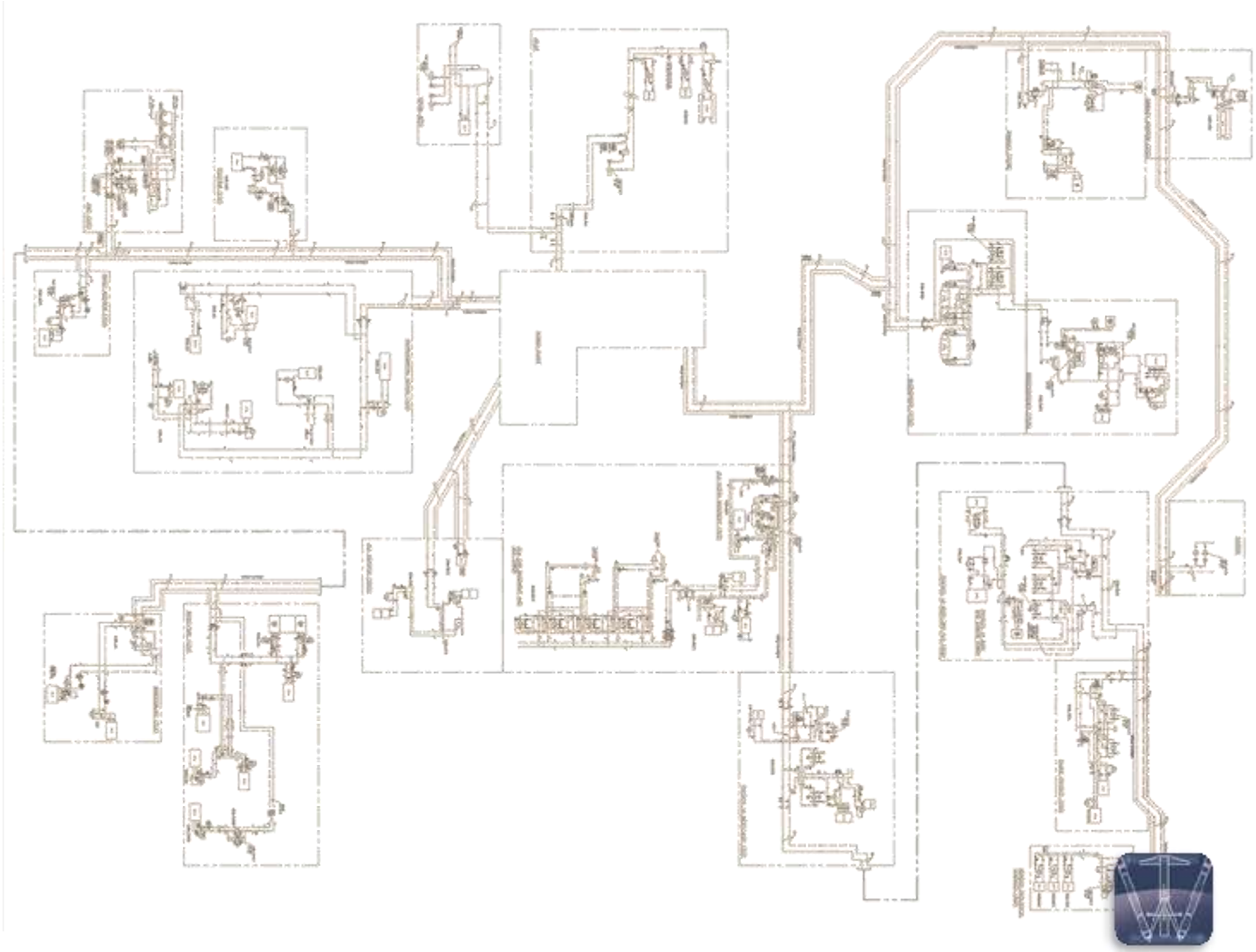
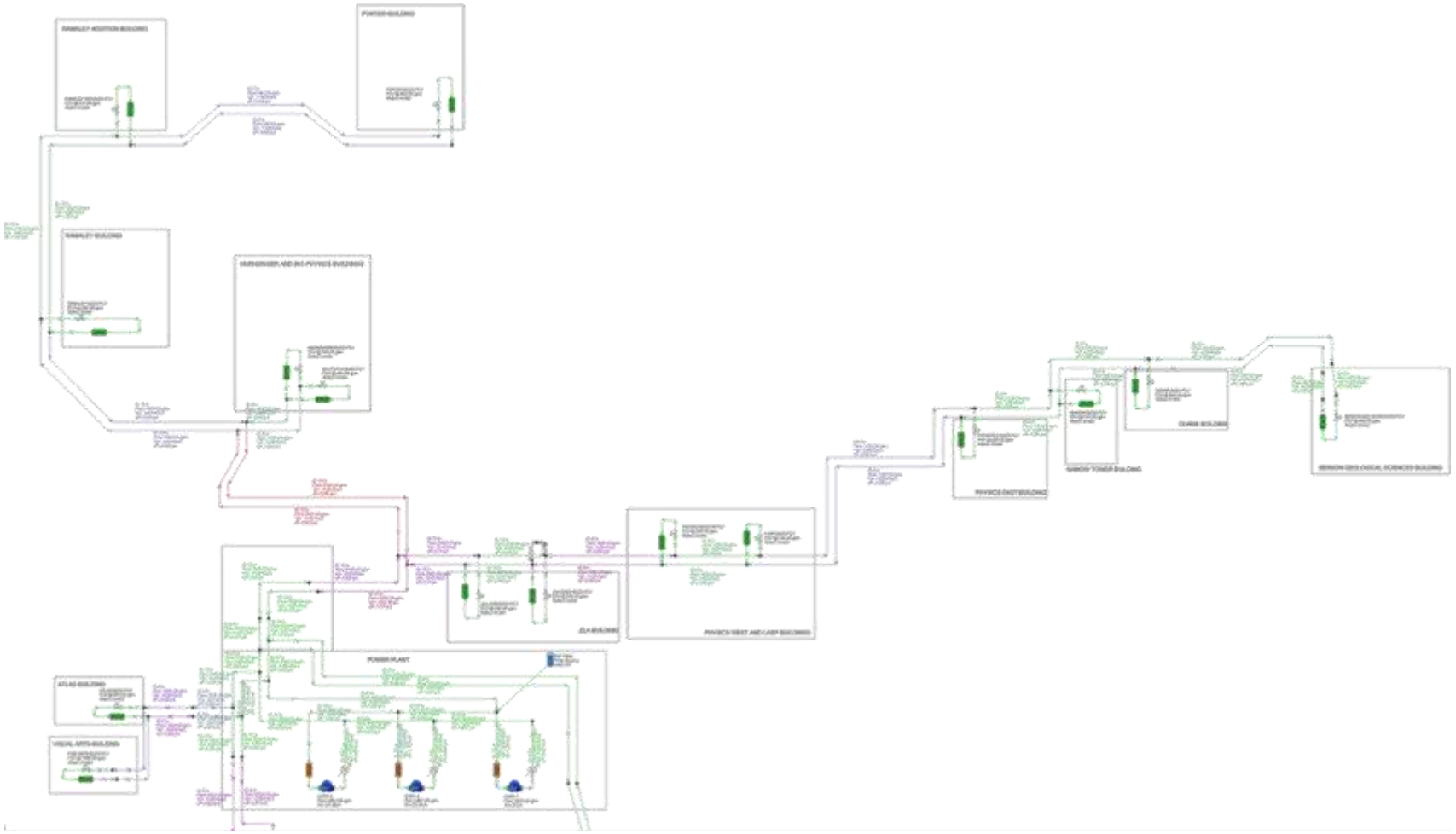
EXISTING INFRAS. ASSESSMENT



EXISTING INFRAS. ASSESSMENT



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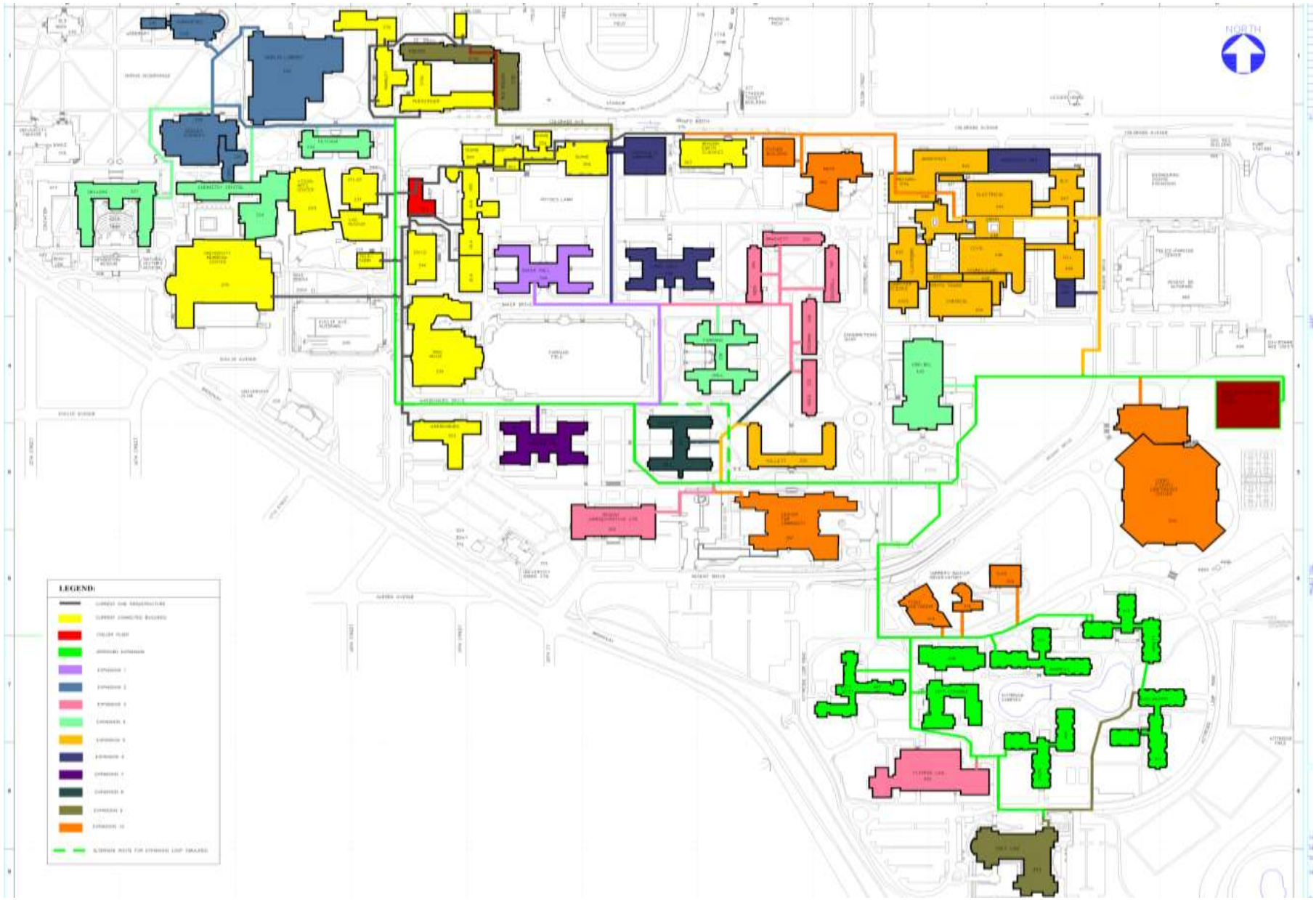
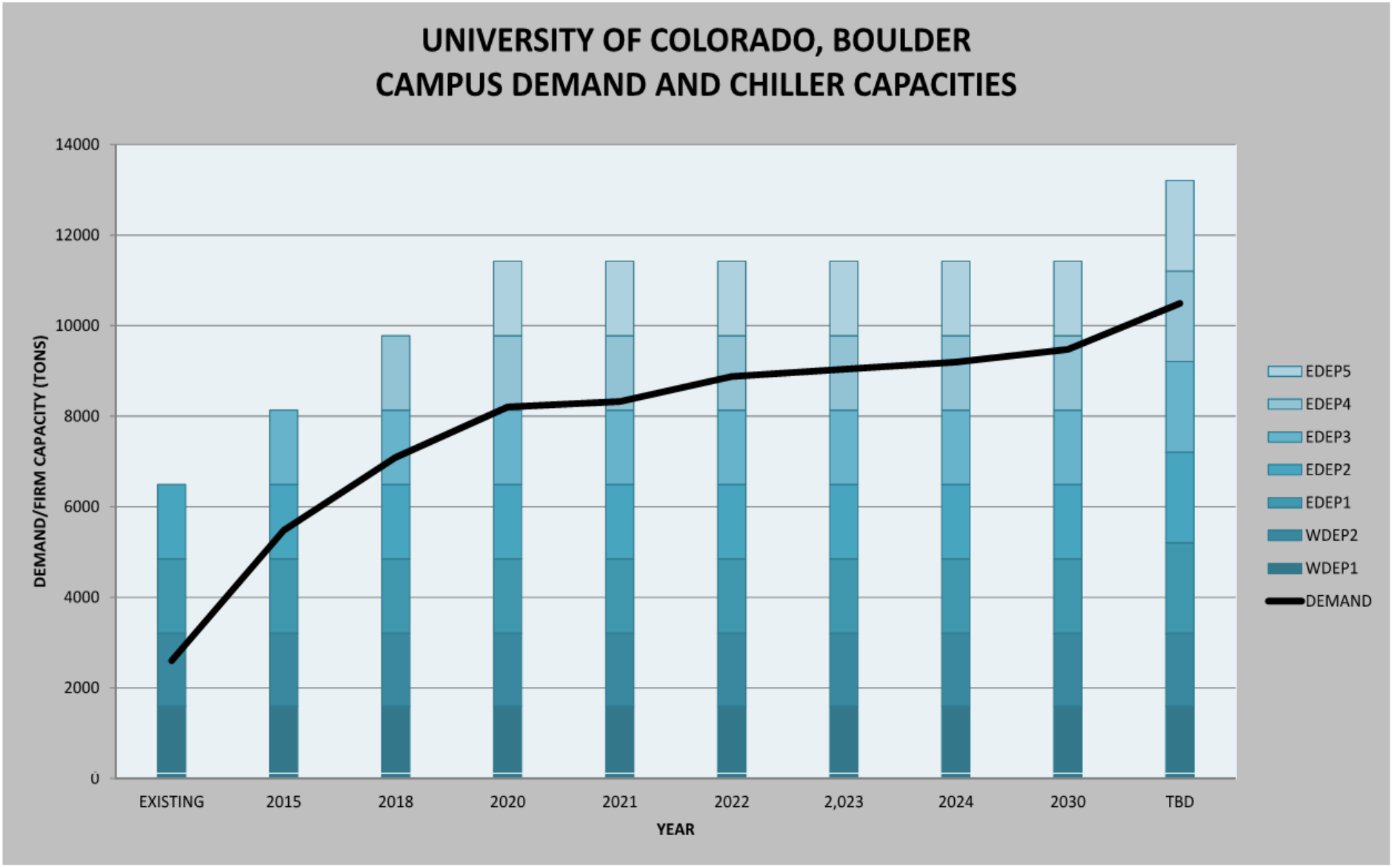
MASTER PLANNING INFRAS. EXP.



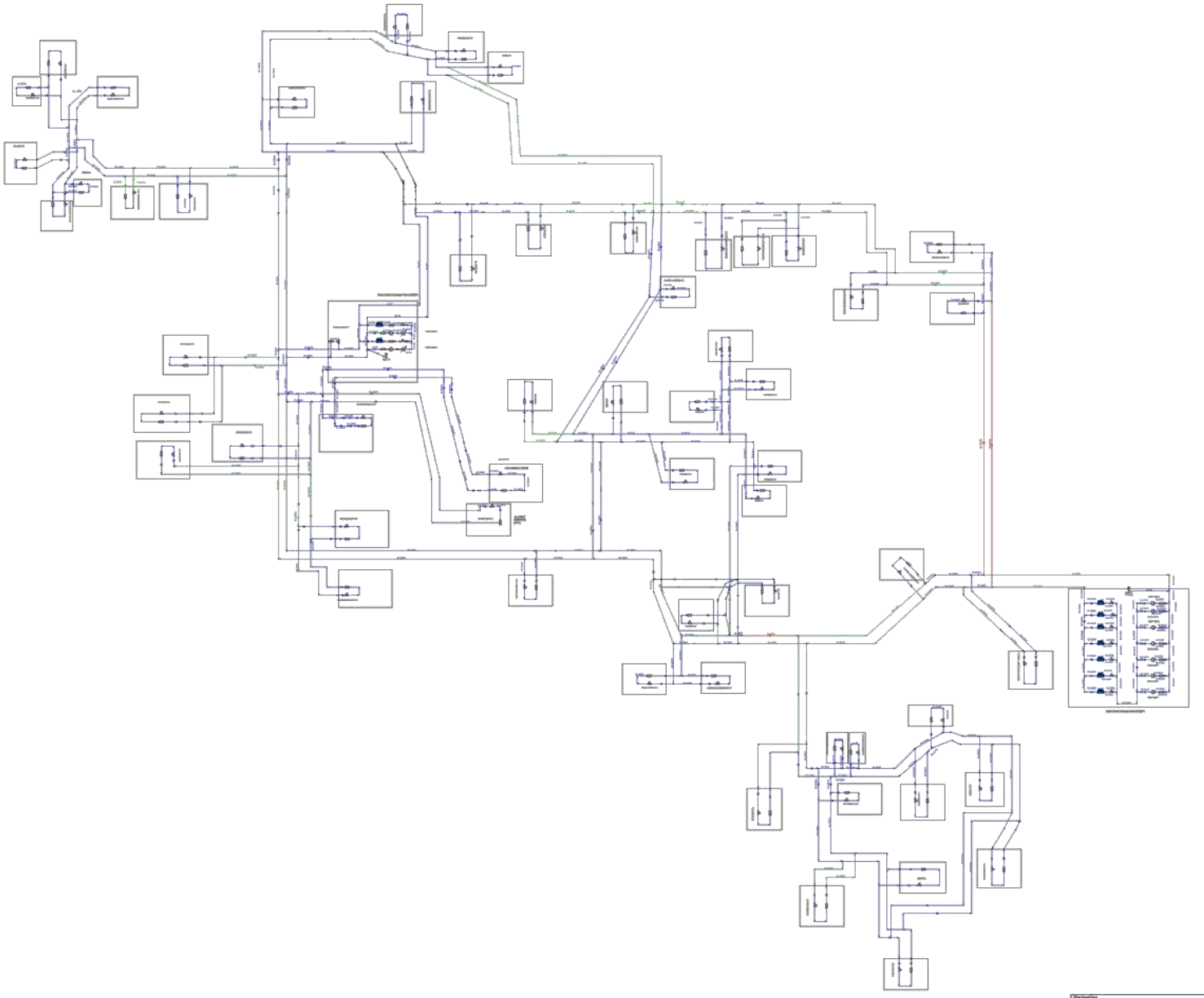
MASTER PLANNING INFRAS. EXP.

PHASE OF CONSTRUCTION	BLDG. NO.	BUILDING NAME	BUILDING TYPE	EXPECTED CONN DATE	CONNECTION SIZE TO CHW LOOP	LOAD FACTOR	SYSTEM DESIGN			SYSTEM COINCEDENTAL PEAK DEMAND	
							PEAK LOAD TONS	DELTA T 10	FLOW GPM	PEAK LOAD TONS	FLOW GPM
CURRENT	231	ATLAS	Laboratory-Light	CONNECTED	6"	86%	215	10	516	141	339
	383	Benson Earth Sciences Bldg	Laboratory-Light	CONNECTED	8"	86%	150	10	360	98	236
	386	Carlson Gymnasium	Office/Classroom	CONNECTED	4"	86%	112	10	269	74	176
	359	Duane Physics	Laboratory-Light	CONNECTED	6"	86%	300	10	720	197	473
	344	Environmental Design Building	Laboratory-Light	CONNECTED	6"	86%	100	10	240	66	158
	334	IMIG Music Building	Office/Classroom	CONNECTED	6"	86%	125	10	300	82	197
	355	JILA	Laboratory-Heavy	CONNECTED	6"	86%	300	10	720	197	473
	355	JILA Addition	Laboratory-Heavy	CONNECTED	4"	86%	50	10	120	33	79
	355	JILA/NIST Addition	Laboratory-Heavy	CONNECTED	6"	86%	150	10	360	98	236
	357	LASP	Laboratory-Heavy	CONNECTED	4"	86%	150	10	360	98	236
	3735	Muenzinger Psych & Biopsych	Laboratory-Light	CONNECTED	8"	86%	400	10	960	263	630
	354	Power House	Office/Classroom	CONNECTED	8"	86%	150	10	360	98	236
	370	Ramaley Biology Building	Laboratory-Heavy	CONNECTED	6"	86%	300	10	720	197	473
	210	Telecommunication Center	Special	CONNECTED	3"	86%	30	10	72	20	47
	205	University Memorial Center	Assembly	CONNECTED	6"	86%	350	10	840	230	551
	229	Visual Arts Complex	Office/Classroom	CONNECTED	8"	86%	550	10	1320	361	867
	324	Wardenburg Student Health Ctr	Medical Clinic	CONNECTED	6"	86%	130	10	312	85	205
APPROVED EXPANSION	407	Andrews	Housing	2013	6"	90%	110	10	264	99	238
	410	Arnett	Housing	2013	6"	90%	110	10	264	99	238
	412	Buckingham	Housing	2013	6"	90%	110	10	264	99	238
	411	Kittredge Central	Office/Classroom	2013	6"	90%	110	10	264	99	238
	408	Kittredge West	Housing	2013	6"	90%	110	10	264	99	238
	409	Smith	Housing	2013	6"	90%	100	10	240	90	216
EXPANSION 1	346	Baker Hall	Housing	2014	8"	90%	200	10	480	180	432
EXPANSION 2	225	CIRES	Laboratory-Heavy	2015	6"	90%	150	10	360	135	324
	226	Ekeley Sciences	Laboratory-Light	2015	8"	90%	300	10	720	270	648
	241E	Humanities Bldg	Office/Classroom	2015	6"	90%	120	10	288	108	259
	245	Norlin Library	Library	2015	12"	90%	610	10	1464	549	1318
	241	Woodbury Arts & Sciences Building	Office/Classroom	2015	3"	90%	30	10	72	27	65
EXPANSION 3	339	Aden Hall	Housing	2018	6"	90%	50	10	120	45	108
	350	Brackett Hall	Housing	2018	6"	90%	50	10	120	45	108
	340	Cockerel Hall	Housing	2018	6"	90%	50	10	120	45	108
	338	Crosman Hall	Housing	2018	6"	90%	50	10	120	45	108
	405	Fleming Law	Office/Classroom	2018	6"	90%	230	10	552	207	497
	332	Reed Hall	Housing	2018	6"	90%	50	10	120	45	108
	309	Regent Administrative Center	Office/Classroom	2018	10"	90%	200	10	480	180	432
EXPANSION 4	224	Cristol Chemistry & Biochemistry	Office/Classroom	2020	8"	90%	590	10	1416	531	1274
	336	Farrand Hall	Housing	2020	8"	90%	250	10	599	225	539
	221	Hellems	Office/Classroom	2020	8"	90%	240	10	576	216	518
	232	Ketchum	Office/Classroom	2020	6"	90%	100	10	240	90	216
	430	Koelbel Business Addition	Office/Classroom	2020	8"	90%	310	10	744	279	670

MASTER PLANNING INFRAS. EXP.



HYDRONIC MODELING



CONCLUSION

- UNDERSTAND AFFECTS OF CHW DEMAND AND SYSTEM FAILURES ON INFRAS.
- DEFINE FUTURE PUMP HEAD AND COOLING CAPACITY EQUIREMENTS
- DEFINE GROWTH PLAN FOR EXPANSION OF CHW INFRAS.
- DEFINE MOST HYDRONICALLY REMOTE BUILDINGS AND DP REQUIREMENTS AT PLANTS
- HYDRONIC MODEL USED TO ANTICIPATE CHANGE AND PLAN FOR THE FUTURE

Juan Suarez

Comissioning Agent

Commissioning objectives & commissioning agent responsibilities

- Represent owner during the construction to assure Project's Objectives are met.
- Verify and Document the Project meets the Owners Project Requirements (OPR)
  - Develop Commissioning Specifications.
  - Develop a Commissioning Plan.
  - Develop Prefunctional Forms.
  - Develop Functional Forms.
  - Site Visits and Reports.
  - Review of Drawings and Submittals.
  - Maintain issues log and recommend who is responsible to resolve the issues.
  - Functional testing.
- Training.
- O & M.
- Final report and lessons learned.

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What makes this project different and challenging for a commissioning agent ?

- The project radically changes the University's present operations of utilities; generation and distribution.
- Impacts all utilities used in campus,
  - Electric power generation. (Adding a turbo steam generator)
  - Chilled water absorbers are replaced by electrical chillers.
  - Chilled water distribution is centralized into the existing WDEP and new EDEP with sufficient capacity for the future.
  - Chilled water distribution backbone installation.
  - Additional Steam Generation in the EDEP.
  - Steam distribution main and steam condensate to tie both plants WDEP with the new EDEP steam generation.
- Both steam and chilled water plant must work as a single unit to provide system redundancy.
- Emphasis on energy efficiency and data collection to reduce cost.
- Centralized SCADA system integrating all existing and new equipment at WDEP and EDEP and the capacity to expand to supervise all the utilities distributions system (power, steam and chilled water) and buildings' BAS systems,etc.

Key commissioning points

- Chilled water distribution:
  - Pressure testing.
  - Pipe flushing.
  - Verification lines are not cross. (supply with return)
  - Pressure drop across lines from plat to different buildings.
- Steam and Condensate distribution:
  - Pressure testing.
  - First time energizing lines; checking expansion joints, anchors, traps and condensate return.
  - Flushing/ blow off pipes.

Key commissioning points

- Chillers :
  - Assure chillers are fully functional during startup.
    - Refrigerant and oil level.
    - Cooling systems, oil and VFDs.
    - All chiller safeties check.
    - Chiller setup for min load.
    - Chiller smooth operations at all loads.
    - Chiller efficiency and capacity.
    - Supply chilled water temperature stability.
  - Communications to plant control system.
  - Communications to SCADA.
- Pumping of chilled water:
  - Staging of pumps and chillers to meet the campus load.
  - Chilled water line pressure control.

Key commissioning points

- Cooling towers:
  - Flushing.
  - Water even distribution thru fill.
  - Water supply system stability.
  - Capacity.
  - Controls functionality and communications to SCADA.
- Boilers:
  - Startup and test of all ancillaries; compressed air, low/medium pressure steam, etc.
  - Startup the feed water systems and recirculation of water thru all tanks an boilers.
  - Start boilers.
    - Check safeties and stability of boiler controls.
    - Check efficiencies of boiler at different loads with two fuels NG and Fuel Oil.
  - Boilers controls communication to the plant master control and central SCADA.
- Controls:
  - Verify operations from pla[illegible]tral controller.
  - Graphics conditions and a[illegible]ura[illegible] of data, alarms and trending.

Key commissioning points

- SCADA:
  - Graphics.
  - Verification of data integrated into SCADA.
  - Trending
  - Verifications of data historicized.
  - Reports.

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