CES502779

Big Innovyze for Small Town in Brazil

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Learning Objectives

- Learn about the interaction between Innovyze and Autodesk solutions.
- Learn about the interaction between Autodesk and Innovyze solutions for dam asset management.
- Learn about the collaborative workflow of Autodesk tools for a dam project.
- Learn about dam-break simulation with the Innovyze solution.

Description

The rupture of the dam in Ayrton Senna Park in Brazil impaired one of the few tourist attractions in a small town in the Brazilian countryside, generating significant social and environmental impact. Schettini Engenharia understood that for this atypical situation, it would be necessary to bring together some strategic partners to develop the entire building information modeling (BIM) solution with the help of geographic information system (GIS) solutions, starting the first smart-city project in the region. Using Autodesk and Innovyze solutions, the firm aimed to adopt sustainable practices in its proposal, mitigating part of the damage caused by the rupture of this dam, and bringing safety and better quality of life to this community. In this challenging dam case study, you'll learn the workflow between the following tools: Autodesk Recap, Civil 3D, Revit, Autodesk Docs, Navisworks, Unity Reflect Review, Innovyze InfoDrainage, and InfoWorks ICM.

Speaker(s)

Fernando Schettini has a degree in Civil Engineering from Dom Bosco Catholic University (2020) located in Campo Grande/MS. Fernando is taking two postgraduate courses (Lato-Sensu), one in Highway Engineering (2022) and the other in BIM for Infrastructure (2022) at IPOS Specialization located in Florianópolis/SC. Civil Engineer with experience in project management for Urban Infrastructure. He is now making the compatibility of executive projects between the following disciplines: paving, drainage, sanitary sewage, water supply, vertical and horizontal signage, public lighting, among other disciplines related to design. He is active in the following topics: BIM, Urban Infrastructure, Cost Engineering, Project Management, Geotechnologies and Smart Cities.

Ryan Brown has over ten years of experience in the water, wastewater, and stormwater industry. He has focused on hydraulic modeling for design, analysis, and other digital applications of water, wastewater, and stormwater-related data systems for much of that time. His expertise also extends to FEMA floodplain compliance and transportation hydraulics design. Ryan Holds a BS in Biosystems Engineering from Clemson University and an MS in Biological and Agricultural Engineering from NC State University. He is a registered professional engineer in the state of North Carolina.

Newton Caxeta is an infrastructure engineer with over 8 years of experience specialized in sanitation system. He is a technical expert in BIM methodology. His expertise also extends to BIM design in such projects as sewer/water pump station, treatment station, water system distribution and sewerage system. Currently working as a Technical Sales Specialist, Newton is focused on understanding the customer’s challenges and problems in order to provide the best solutions for them. He holds a BS degree in Civil Engineering from FAAP and an AS degree in Building Construction Technology from FATEC-SP. He is currently completing his post-graduate study in BIM Design Infrastructure at PUC-MG.

Raírio Mota is an infrastructure designer with 2 years of experience in road geometry, earthmoving and urban drainage with BIM methodology. He also has experience in building and MEP design. He is currently working as a Civil 3D Instructor, providing training on the software for road, earthmoving, and drainage design. Raírio is completing his BS degree in Civil Engineering by the end of 2022 at the State University of Feira de Santana - BA, writing his final undergraduation paper on interoperability between BIM software in an urban infrastructure project. He's graduated as a Building Technician at Federal Institute of Technology - BA and is doing a post-graduation in BIM Transportation Infrastructure at EBPÓS.

Matheus Barros has experience in Urban Land Development and Transportation Infrastructure Projects with Autodesk Solutions. His expertise includes BIM design of urban roads, highways and sanitation systems. Experience in BIM Management for Infrastructure Design. Matheus holds a BS degree in Civil Engineering from University of Brasilia (UnB), Brasilia, Brazil. A MS degree in progress in Geotechnics from UnB including topics as BIM GIS Integration and Geotechnical BIM. Also, a ME degree in BIM Management for Infrastructures from Zigurat Global Institute, Barcelona, Spain. He has experience in Infrastructure Design at RHUMB, and is a Content Creator at Build Lab Academy by FF Solutions.

Contextualization

Caarapó, Mato Grosso do Sul, Brazil

Caarapó is a city located in the southwest of the state of Mato Grosso do Sul, which belongs to the Midwest region of Brazil.

It is a small and recent city with less than 40,000 inhabitants and 56 years of existence, and stands out economically for its agriculture. Previously, the city exploited yerba mate, which was abundant in the region. The origin of the city's name is *yerba mate* in an indigenous language of the region. Nowadays, the main crop planted is sugar cane.

Ayrton Senna Park and Diego Cuê Dam

Caarapó has few public areas for recreation. One of these few places is the Ayrton Senna Park, whose main attraction is the Diego Cuê stream dam, and its lake is used for recreational purposes.

Figure 1 – Ayrton Senna Park

In 2015, during the rainy season, a set of factors such as poor conservation of the dam structure over the years, and intense and atypical rains for the region led to the geotechnical collapse of the dam, generating enormous socio-environmental impacts, both for the population and for the Diego Cuê stream ecosystem.

Figure 2 – Diego Cuê Dam

Schettini Engenharia and Vertrio

Schettini Engenharia, an urban infrastructure project company, with more than 30 years of experience and active in the Brazilian Midwest region, was hired in 2017 to develop a project with conventional methodology (projects with 2D representations). Until then, the company was not using the BIM methodology in all its projects.

In 2021, Schettini Engenharia started a new company called Vertrio with the purpose of carrying out innovation, for the companies of the Schettini group and for other private or public companies in the following pillars of action: processes, technology and people.

Over the years we had the opportunity to work on several projects for the urban infrastructure of the city of Caarapó, accumulating experience with the characteristics of the region.

Taking advantage of the familiarity with the city of Caarapó and its small proportions, Vertrio chose the city as its pilot project to use the BIM methodology in urban drainage, basic sanitation, water supply and the Diego Cuê stream dam. We revisited the projects developed over the last 10 years for the city of Caarapó and started developing the projects using the BIM methodology. In this way, we will be able to analyze performance for technical and managerial production.

Challenges of this project

Small cities have complex problems due to low tax collection, so public management suffers from low innovation capacity. This fact makes the emergence of new technologies and methodologies to help deliver better public services difficult.

Vertrio seeks to assist in these difficulties, bringing maturity in the development of projects for urban infrastructure, monitoring and management during the execution of works, and management and monitoring of underground infrastructure assets using the BIM methodology. Providing more conscious decisions for scarce public resources.

Proposed solutions

We pioneered in Brazil the set of solutions from Autodesk, Innovyze and Unity to carry out the projects for the Diego Cuê dam, which had its construction begun in June 2022.

We are monitoring the evolution of the construction and validating the project during meetings with the company responsible for the execution of the work. The work on the new dam should last around 8 months.

We will introduce below in detail the workflow developed to achieve interoperability between Autodesk AEC, Innovyze and Unity package solutions. We generate the necessary documentation to meet the standardization of ISO 19650 for the BIM methodology using the solutions: Plannerly and Bizagi.

Preliminary Tasks and CDE

Preliminary Tasks

The original design was executed in 2D, that is why we had some data to initiate our BIM design, which are:

- Hydrological data;
- Geotechnical data;
- Conventional topography surveying.

In terms of hydrology, the hydrological data were collected from meteorological stations belonging to the Instituto Nacional de Meteorologia (National Meteorology Institute). The chosen station adopted was the pluviometric station 2254000, located in the city of Dourados/MS.

The period analyzed was from 1974 to 2009 with an annual compost series of 25 samples. December, January and February were the rainiest and June, July and August were the driest.

Figure *3* and Figure 4 show location and Intensity, Duration and Frequency Curves.

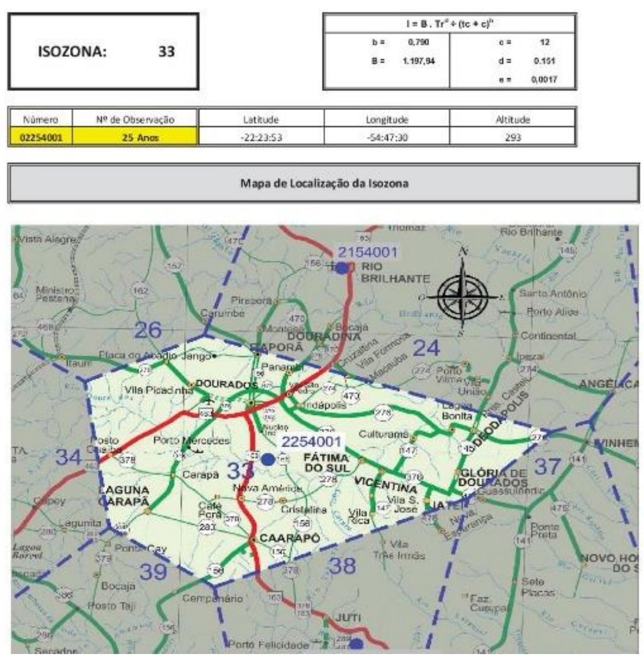


Figure 3 - Map of Caarapó. Source: IBGE

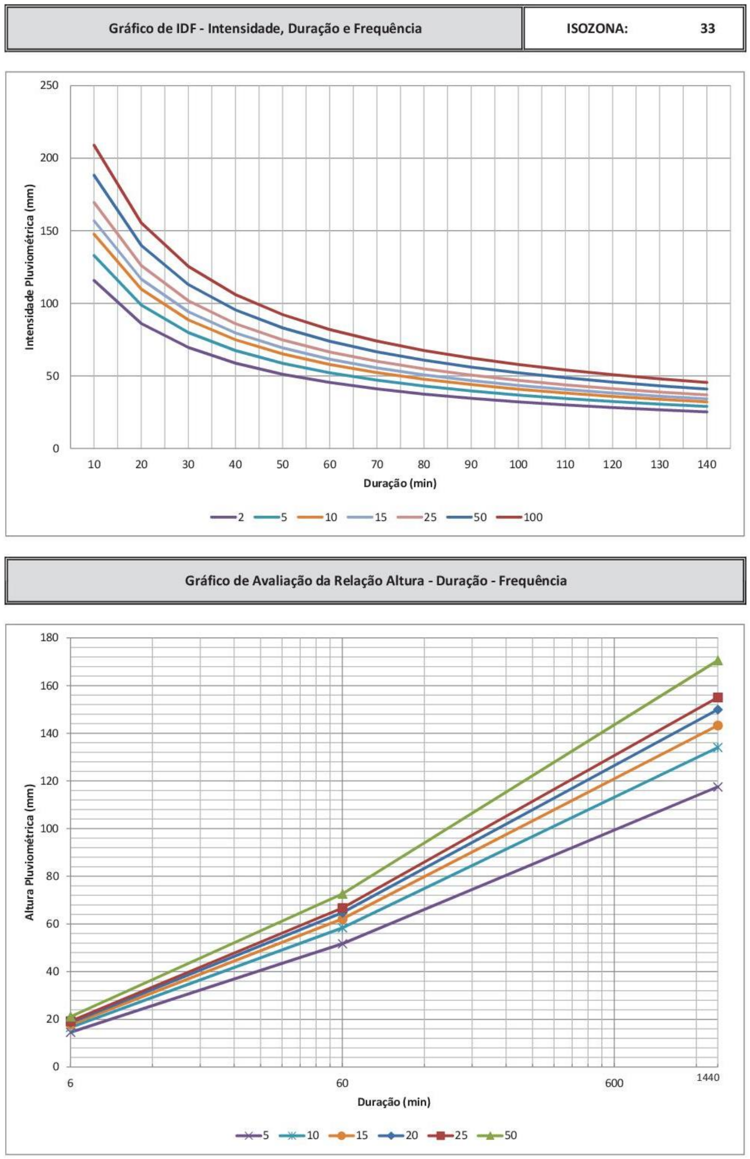


Figure 4 – Intensity, Duration and Frequency Curves. Source: Figueiredo e Miyasato (2013)

Due to the size of the design, it was necessary to carry out two types of drilling for the geotechnical studies, which served as the basis for the design. First, the auger drilling was carried out, whose main goal is to bring the types of materials in each pre-delimited region, Figure 5 (a) shows all details (information in Portuguese).

The second was the percussion sounding, with the goal of bringing more details at greater depths, load support in each region and among other data. Figure 5 (b) shows information about the SPT-02 hole as an example, and Figure 5 (c) shows some of the investigations carried out for this design.

(a)

Orgao: AGESUL - Agência Estadual de Gestão de Empreendimentos — BOLETIM DE SONDAGEM A TRADO DO SUB LEITO

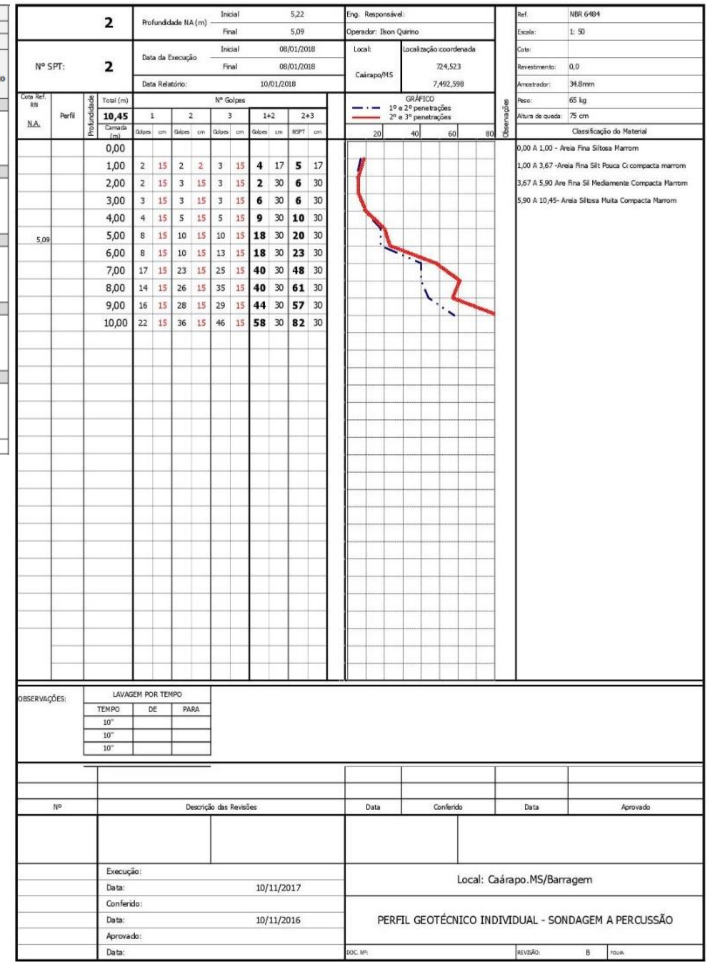
Obra: PROJETO GEOTECNICO DE BARRAGEM — CAARAPÓ / MS

TABELA DOS FUROS DE SONDAGENS E ENSAIOS DE SUB-LEITO

Nº	PROFUNDIDADE (m)	N.A (m)	CLASSIFICAÇÃO EXPEDITA	COORDENADAS UTM (DATUM: SIRGAS 2000) E	COORDENADAS UTM (DATUM: SIRGAS 2000) N	L.L	I.P	GRANULOMETRIA - % QUE PASSA NAS PENEIRAS 1"	3/8"	nº 4	nº 10	nº 40	nº 200	I.G	CLASSIFICAÇÃO H.R.B	COMPACTAÇÃO Energia: P.I. HOT (%)	DEN. MAX. Kg/m³	I.S.C. Exp.	ISC (%)	Comportamento geral como subleito
AMOSTRA 01 CAIXA DE EMPRESTIMO 02																				
AM01 E	0,00 - 0,12	NE	AREIA LAVADA	724.637	7.492.736	NP	NP	100	100	100	100	96.16	33.54	0	A-2-4	8.5	2037	0,00	37.9	BOM
	0,12 - 2,00		AREIA SILTOSA MARROM																	
AMOSTRA 02 CAIXA DE EMPRESTIMO 03																				
AM02 E	0,00 - 0,13	NE	AREIA LAVADA	724.433	7.492.254	NP	NP	100	100	100	100	99.20	36.75	0	A-4	8.6	2027	0,00	37.4	BOM
	0,13 - 2,00		AREIA POUCA ARGILOSA MARROM																	
AMOSTRA 03 CAIXA DE EMPRESTIMO 01																				
AM03 E	0,00 - 0,14	NE	AREIA LAVADA	724.499	7.492.854	28.4	6.1	100	100	100	100	98.18	40.87	0	A-4	8.2	2018	0,00	39.9	BOM
	0,14 - 2,00		AREIA POUCA ARGILOSA MARROM																	
FURO 01 TALUDE																				
F01 E	0,00 - 0,06	NE	AREIA LAVADA	724.972	7.492.921	NP	NP	100	100	100	100	93.16	21.37	0	A-2-4	7.0	2008	0,00	38.9	BOM
	0,06 - 2,00		AREIA SILTOSA MARROM																	
FURO 02 TALUDE																				
F02 E	0,00 - 0,06	NE	AREIA LAVADA	724.561	7.492.611	NP	NP	100	100	100	100	95.11	27.90	0	A-2-4	8.4	1970	0,00	37.4	BOM
	0,06 - 2,00		AREIA SILTOSA MARROM																	

N. A. = Nível d'água
N. E. = Não encontrado

(b)



Nº SPT: 2 — Profundidade NA (m): Inicial 5,22; Final 5,09 — Data da Execução: Inicial 08/01/2018; Final 08/01/2018 — Data Relatório: 10/01/2018

Eng. Responsável: — Operador: Ilson Quirino — Local: Caárapo/MS — Localização coordenada: 724,523; 7,492,598

Ref.: NBR 6484 — Escala: 1: 50 — Cota: — Revestimento: 0,0 — Amostrador: 34.8mm — Peso: 65 kg — Altura de queda: 75 cm

Total (m): 10,45 — N.A.: 5,09

Profundidade Camada (m)	1 Golpes	1 cm	2 Golpes	2 cm	3 Golpes	3 cm	1+2 Golpes	1+2 cm	2+3 NSPT	2+3 cm
0,00										
1,00	2	15	2	2	3	15	4	17	5	17
2,00	2	15	3	15	3	15	2	30	6	30
3,00	3	15	3	15	3	15	6	30	6	30
4,00	4	15	5	15	5	15	9	30	10	30
5,00	8	15	10	15	10	15	18	30	20	30
6,00	8	15	10	15	13	15	18	30	23	30
7,00	17	15	23	15	25	15	40	30	48	30
8,00	14	15	26	15	35	15	40	30	61	30
9,00	16	15	28	15	29	15	44	30	57	30
10,00	22	15	36	15	46	15	58	30	82	30

Classificação do Material:
0,00 A 1,00 - Areia Fina Siltosa Marrom
1,00 A 3,67 -Areia Fina Silt Pouca Cc compacta marrom
3,67 A 5,90 Are Fina Sil Mediamente Compacta Marrom
5,90 A 10,45- Areia Siltosa Muita Compacta Marrom

OBSERVAÇÕES:

LAVAGEM POR TEMPO		
TEMPO	DE	PARA
10"		
10"		
10"		

Nº	Descrição das Revisões	Data	Conferido	Data	Aprovado

Execução: — Data: 10/11/2017 — Conferido: — Data: 10/11/2016 — Aprovado: — Data:

Local: Caárapo.MS/Barragem

PERFIL GEOTÉCNICO INDIVIDUAL - SONDAGEM A PERCUSSÃO

DOC. Nº: — REVISÃO: B — FOLHA:

(c)

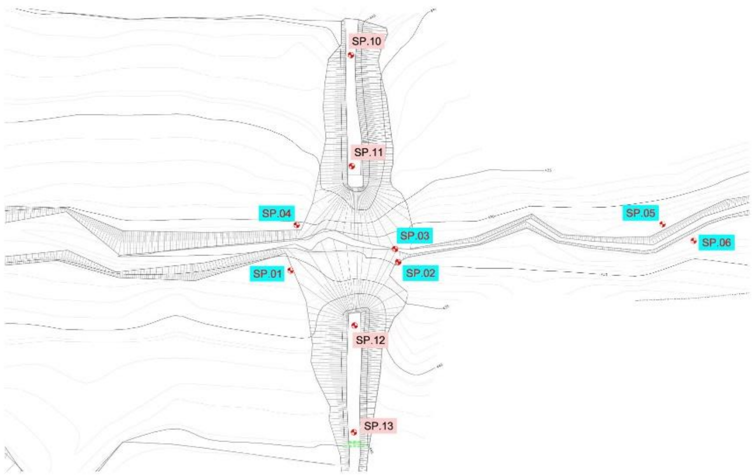


Figure 5 – (a) Auger Drilling Data, (b) Standard Penetration Test (SPT) Report and (c) Location of Investigations. Source: Schettini Engenharia

The last data collected for the BIM design was the conventional topographic surveying. The 2D design was executed based on it.

This same topography served to input real data into the project that we are presenting to you here, such as BIM design and simulation, for example. Launching several closed traverses along the terrain, in each demarcation a topographic survey was carried out using GPS RTK. A total of 1,838 notable points in 43.035100 ha effectively surveyed were promoted at the site, resulting in a density of more than 46 points per ha, that is, the area would be covered by a mesh of less than 20 m x 20 m. The job developed is classified as Cadastral Planialtimetric Survey – class I – TAC, according to NBR 13.133/94.

Also, a drone flight was done after the 2D design, precisely to kick-start this BIM design with the Autodesk solutions that we are presenting here. The equipment used for this job was eBee X with camera S.O.D.A. The idea is to mix topographic data, the points collected by the topography in the field plus the drone flight, so we could increment the point cloud in the workflow. Figure 6 show the terrain with the drone's vision.

After gathering these data, it was necessary to create the BIM Execution Plan, discussed in the following topics.

Figure 6 – Drone Flight. Source: Schettini Engenharia

CDE

Our team is in many different regions of the world, like North Carolina in the US and São Paulo, Campo Grande, Feira de Santana and Brasília in Brazil. We needed one Common Data Environment (CDE); it would be impossible to work sending e-mail or other way to change information about the design. For this reason, we used Autodesk Docs.

The activities performed after the creation HUB in Autodesk Docs were:

- Organize the structure folder;
- Insert all preliminary data;
- Develop the design;
- Create the PPT presentation.

In Figure 7 and Figure 8 it is possible to see some parts of Autodesk Docs.

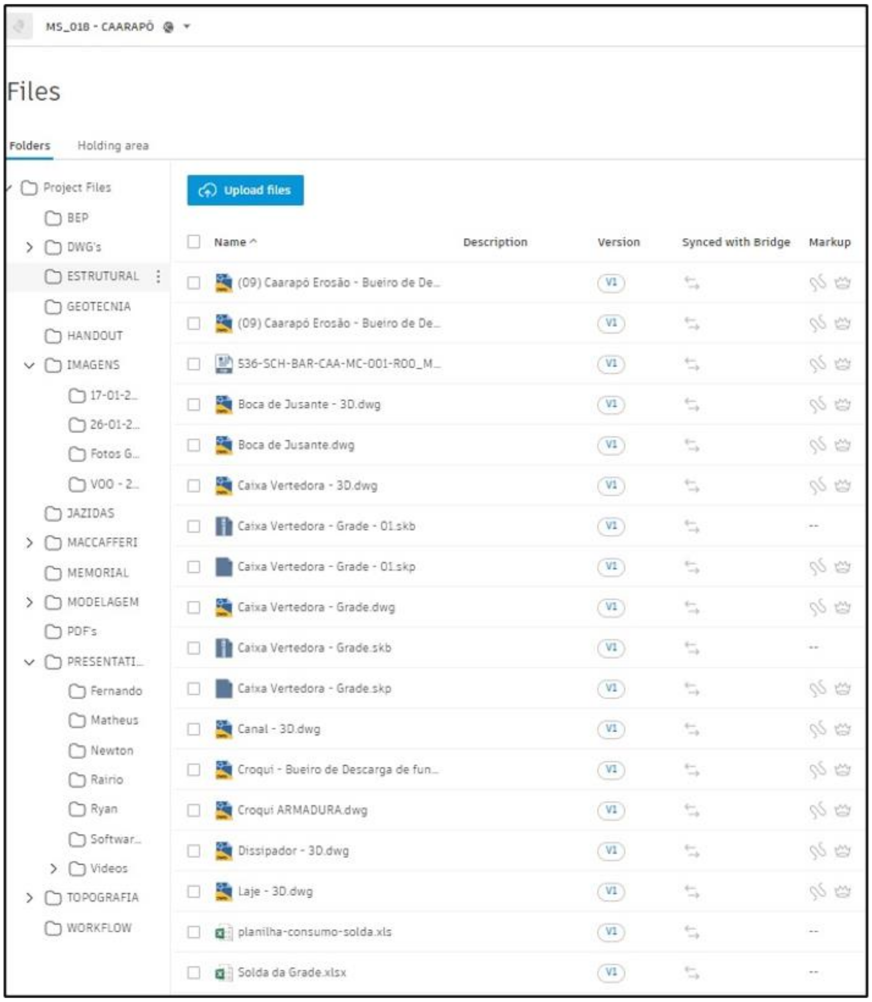


Figure 7 – Dashboard of Autodesk Docs

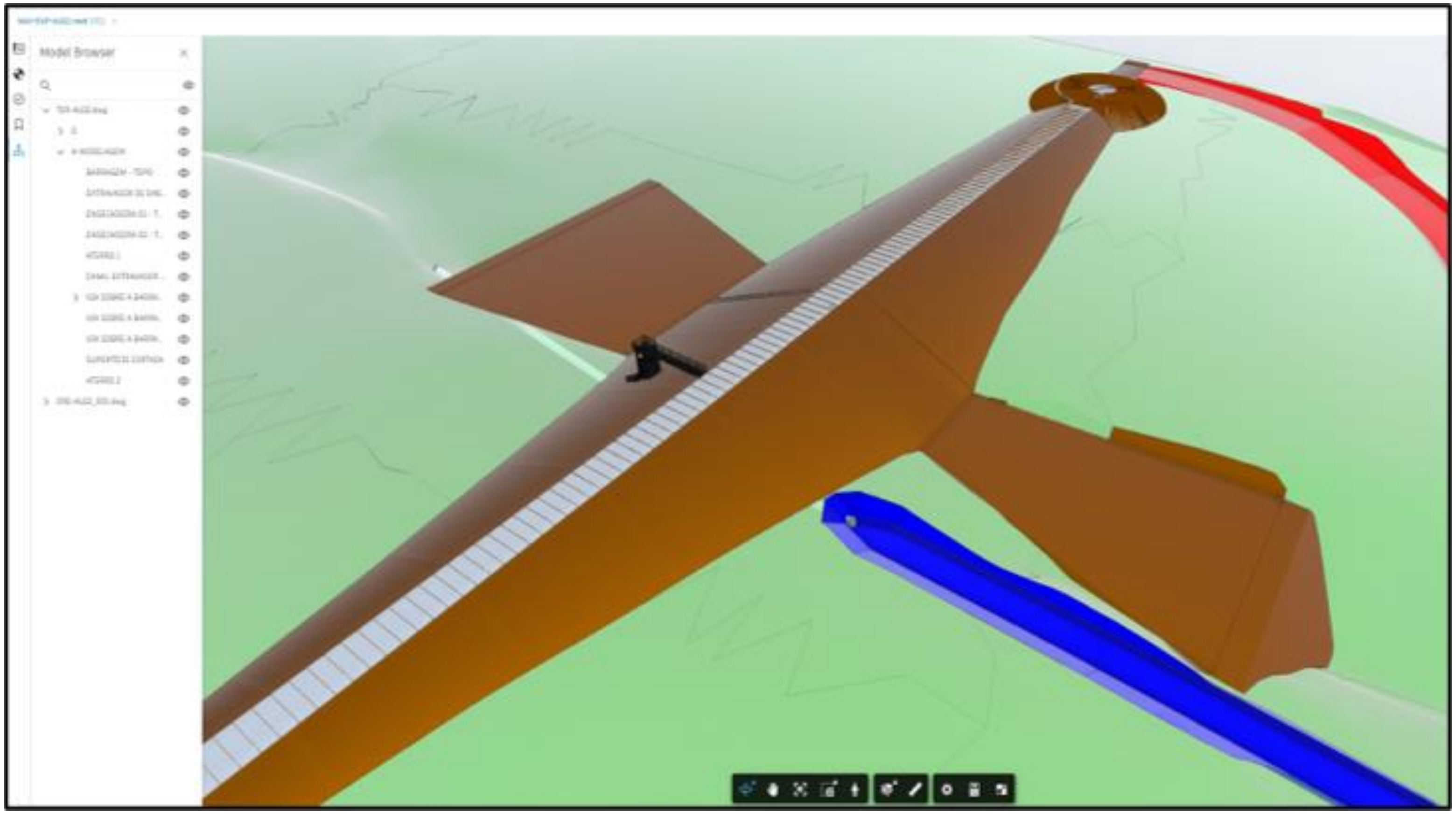


Figure 8 – Dashboard of Autodesk Docs

BIM Management

In this topic the main aspects of the platform used for BIM Management and the BIM Execution Plan (BEP) will be covered.

About Plannerly

Plannerly is a user-friendly platform for BIM Management used in more than 130 countries by more than 50 thousand people. It is a web-based platform, there is no installation needed. Plannerly allows to work collaboratively in real-time, which contributes to reduce reworks in project processes and improves teams' communication through Smart Lean BIM.

An interesting aspect of Plannerly is the possibility of using templates. For this project we used the ISO 19650, the series of standards for organization and digitization of information about buildings and civil engineering works, including building information modeling (BIM). The template content was adapted to the current project context.

Plannerly has six modules, which in this project were used the PLAN and SCOPE modules.

- PLAN: for BIM documentation, as BEP, information requirements and more;
- SCOPE: for geometry, documentation and information management in a visual way;
- CONTRACT: for contract management;
- SCHEDULE: for efficient task management and creation of schedules;
- TRACK: for progress tracking;
- VERIFY: for BIM models checking.

The following topics will describe the management process with PLAN module to create the BEP and SCOPE module for visual management. Figure 9 shows Plannerly interface. For more information, you may check the website: https://plannerly.com/.

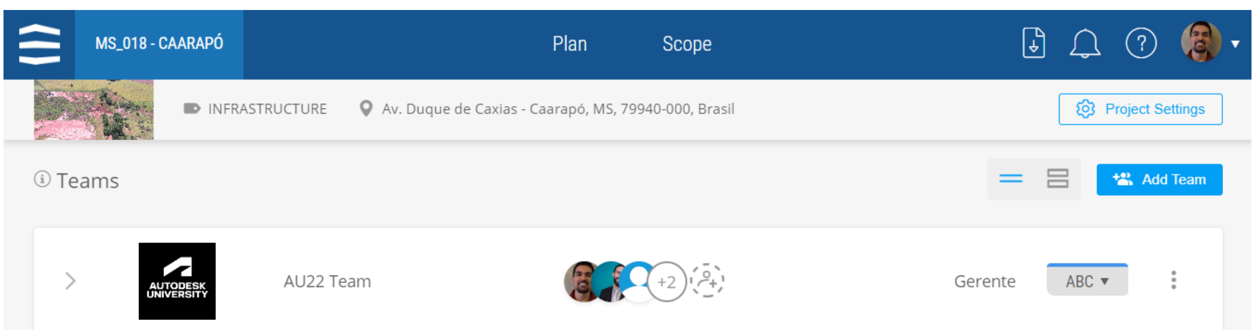


Figure 9 – Plannerly Interface

Basic Information

The basic project information was collected and inserted into Plannerly ISO 19650 template for BEP, such as start and end dates, scope, appointing party requirements, contract number and registration documents from local institutions.

Project Management

We focused on the main keys of BIM: people, processes and technology.

In people aspect, we first defined the intended BIM Uses for the project. According to Succar from BIM Initiative, the following BIM Uses were defined as part of the scope:

- Conceptualization;
- Surveying;
- Laser Scanning;
- Design Authoring;
- Design Reviews;
- 3D Coordination;
- Clash Detection;
- Disaster Planning;
- Risk and Hazard Assessment;
- 2D Documentation;
- 3D Detailing;
- Augmented Reality Simulation (AR).

For each BIM Use, a description according to Succar from BIM Initiative, the priority and life cycle phase were defined, as shown in Table 1.

Table 1 – BIM Uses in Plannerly

BIM Use	Description	Priority (High/Med/Low)	Plan/ Design/ Construct/ Operate			
			P	D	C	O
Conceptualization	Conceptualization is a **Model Use** allowing the initial investigation of design possibilities and spatial requirements. Conceptualization occur during the **Conceptual Design** sub-phase and may utilize specialized **Spatial Analysis Tool**s.	Med	x			
Surveying	A **Model Use** where 3D models are used to establish the dimensional relationships, including horizontal distances, elevations, directions, and angles, on the earth's surface. Surveying is typically used to locate property boundaries, generating maps and establishing construction layout.	Low	X	X		
Laser Scanning	A **Model Use** representing the process of rapid generation of **Point Cloud** data of as-built structures, terrain and vegetation using a fixed, mobile or airborne **3D Laser Scanner.**	Low	X	X		
Design Authoring	A **Model Use** representing the process of developing **Generative Model**s or **Parametric Model**s for design exploration, design communication and design iteration purposes. Design authoring is a key BIM activity leading to model-based **2D Documentation**, **3D Detailing** and other model-based deliverables.	Med		X		
Design Reviews	Review of the Design Model, defined as an object-based 3D model generated by the Design Team (individually or as a group) for the purposes of design analysis .	Low		X		

The team members defined the BIM Roles in order to fulfill the BIM Uses. A responsibility matrix was developed to contribute to this.

- BIM Manager – Matheus.
- BIM Coordinator – Fernando.
- BIM Modeler – Raírio.
- BIM Analysts – Newton and Ryan.

In the aspect of processes, workflows were defined with milestones for delivery control, the frequency and format of project meetings, project standards, such as engineering standards and file naming, and quality control processes for the models delivered, according to the BIM Uses.

For software management, we defined for each software from Autodesk, Innovyze and Unity, discipline, use in the project and version as on Table 2. Common Data Environment (CDE) good practices, file formats to contribute interoperability and hardware specifications were also contemplated.

Table 2 – Software Managament in Plannerly

DISCIPLINE	USE	SOFTWARE	VERSION	ICON
All	BIM Management Platform	Plannerly	Always Current	
Common Data Environment (CDE)	File Sharing	Autodesk Construction Cloud	Always Current	AUTODESK CONSTRUCTION CLOUD
Topography	Design	Autodesk Recap Pro	2023	R PRO
Geometry	Design	Autodesk Civil 3D	2023	C C3D
Earthmoving	Design	Autodesk Civil 3D	2023	C C3D
Drainage Systems	Design	Autodesk Civil 3D	2023	C C3D
Structures	Design	Autodesk Revit	2022	R
Reservoir Simulations	Design	Innovyze InfoWorks ICM	2023.0	I
All	Visualization	Autodesk Infraworks	2023	I IWX
All	Visualization	Unity Reflect View	2023	unity Reflect
All	Coordination	Autodesk Navisworks	2023	N
All	Coordination	Autodesk Construction Cloud	Always Current	AUTODESK CONSTRUCTION CLOUD

Modeling and Design

In this topic the main aspects of Modeling and Design with Autodesk Civil 3D and Revit will be covered.

Initial Steps

All modeling was based on the existing 2D designs, by Schettini Engenharia. Through external references (XREF), drawings and 2D details were inserted into Civil 3D. The templates from Country Kit Brazil, DNIT and SANEAMENTO, were used as a start of customization to attend the company's standards and needs for each discipline.

The topographic data collected by traditional surveying and drone flights was imported into Civil 3D as COGO points and point clouds. With this data, the existing ground surface was created, as a Triangular Irregular Network (TIN).

Figure 10 – Existing Ground Workflow

Geotechnical Data

For the geotechnical data visualization, we used Geotechnical Modeler in Civil 3D 2023. There were two types of investigations on existing ground: hand auger and standard penetration tests (SPTs). Geotechnical data, especially in Brazil, lack standards and each company delivers the results in a specific pattern.

After the uniformization of the data, with the Autodesk Sample Files for Geotechnical Modeler, everything was summarized in a single CSV file. The CSV file was imported into Civil 3D. 2D profile with geological description, called sticklogs, and 3D borehole views were created, as shown in Figure 11.

For more information about Geotechnical Modeler, you may check Autodesk Support: https://knowledge.autodesk.com/support/civil-3d/learn-explore/caas/CloudHelp/cloudhelp/2022/ENU/Civil3D-GeoTech/files/Civil3D-GeoTech-What-Is-the-Geotechnical-Modeller-html-html.html.

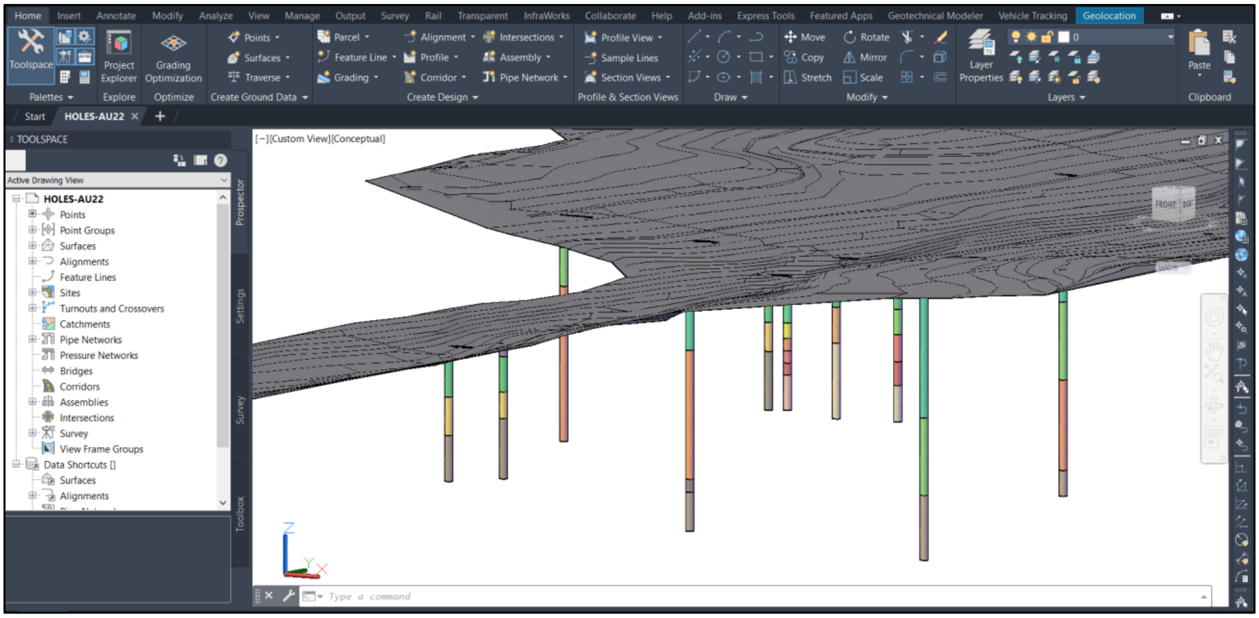


Figure 11 – 3D Boreholes in Civil 3D

Disciplines Organization

The design was organized into four disciplines to facilitate future adjustments and decrease the processing required for each file: geometry, earthmoving, drainage and architecture. Between the disciplines in Civil 3D, Data Shortcuts were used for some elements, while the Revit file was inserted as an external reference, as it can be seen in the flowchart below.

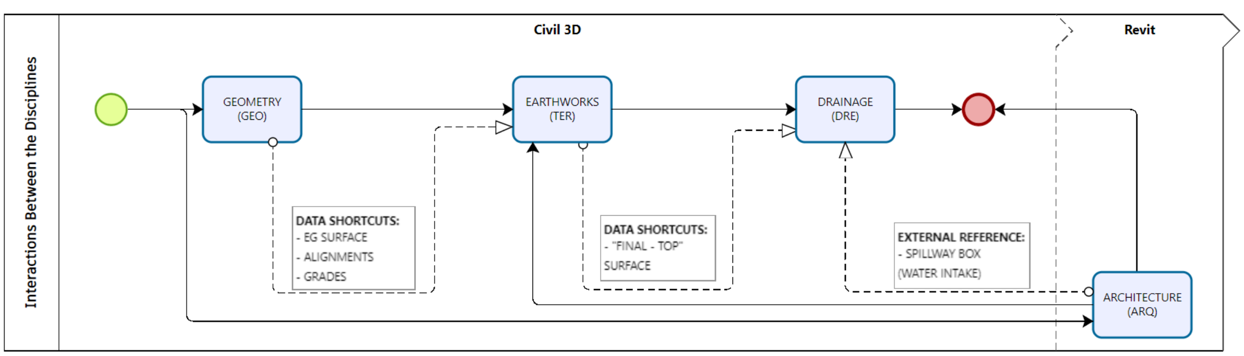


Figure 3 – Interactions between the disciplines

For the earthmoving discipline, geometry Data Shortcuts were used with the surface that represents the existing ground, the alignments and grades of the cofferdams, dam, overflow channel, emergency spillway and the access roads. In the drainage discipline, a Data Shortcut of the final design surface from the earthmoving discipline was used to drawn the pipes and structures.

The first discipline developed was geometry, called GEO. In this discipline, initially were drawn the alignments and longitudinal profiles of the axes of the cofferdams 01 and 02, the dam, the overflow channel, emergency spillway and access roads.

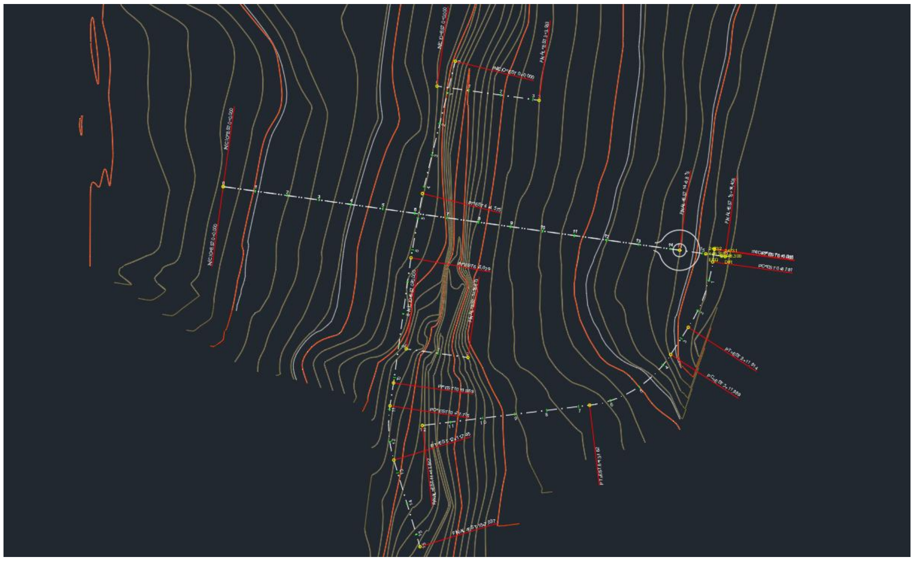


Figure 12 – GEO discipline in Civil 3D

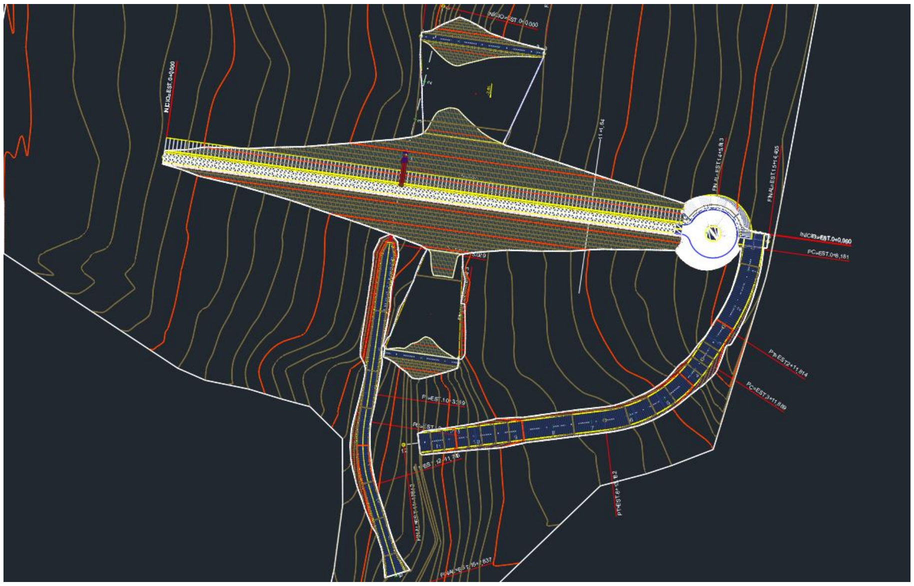


Figure 13 – TER discipline in Civil 3D

The second discipline was Earthmoving (TER), in which the cross-section Assemblies were defined, the cofferdams, dam, overflow channel, emergency spillway and access roads corridors were created, and then the design surfaces were generated. The embankments between the cofferdams and the dam were also modeled with the tools Feature Lines and Grading.

We tried to follow the construction sequence when creating the design surfaces, modeling the two cofferdams, the overflow channel, the dam, the embankments, the emergency spillway, and the access roads, in that order. A "FINAL - TOPO" surface was generated with gradings and the top links of the corridors, to be used in other moments of the modeling and simulations.

Subsequently, the drainage discipline (DRE) was prepared, in which the pipes were drawn with the Civil 3D Pipe Network tools. A Null Structure was used to make the connection between pipes.

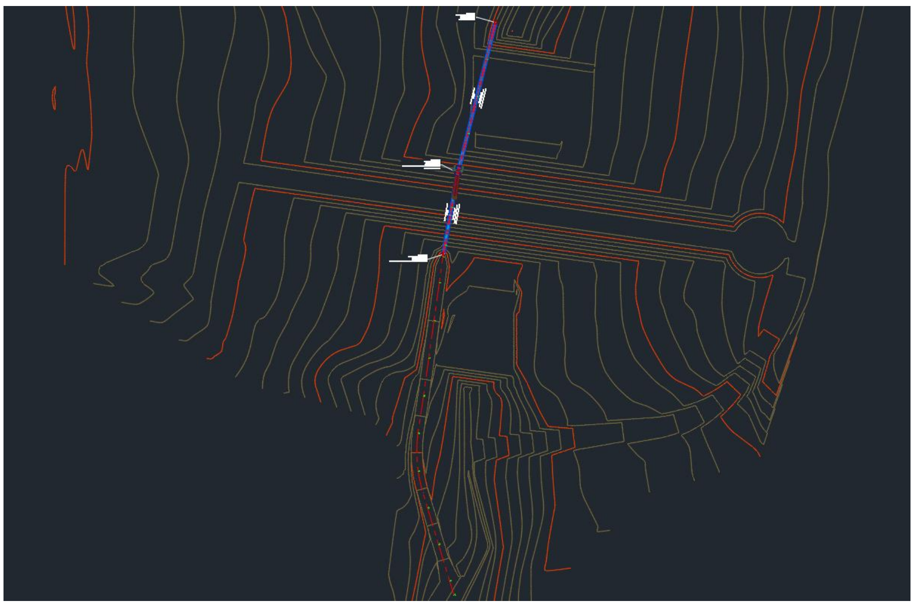


Figure 14 – DRE discipline in Civil 3D

The architecture discipline (ARQ) was developed in Revit, where the spillway structure was modeled. The tools Wall, Floor, Beams (structure) and Guardrail were used to develop the model.

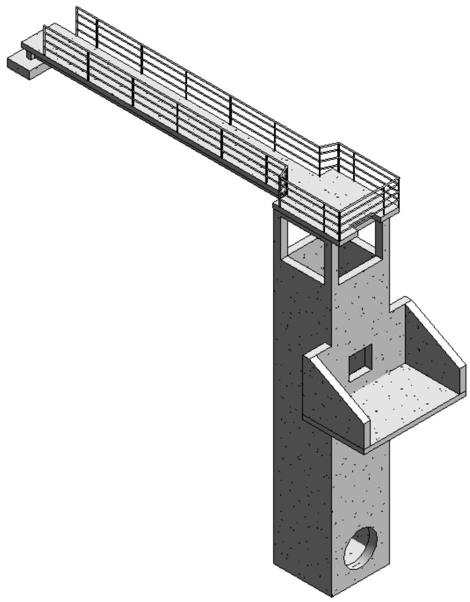


Figure 15 – ARQ discipline in Revit

Interoperability between Civil 3D and Revit

To properly coordinate the Revit and Civil 3D models, the Share Reference Point tool and Desktop Connector were used, as demonstrated by Michael Hurtado at Autodesk University 2019.

You may find Michael's presentation in the following link: https://www.autodesk.com/autodesk-university/class/Coordinating-Civil-3D-and-Revit-Shared-Reference-Points-and-Desktop-Connector-2019#video.

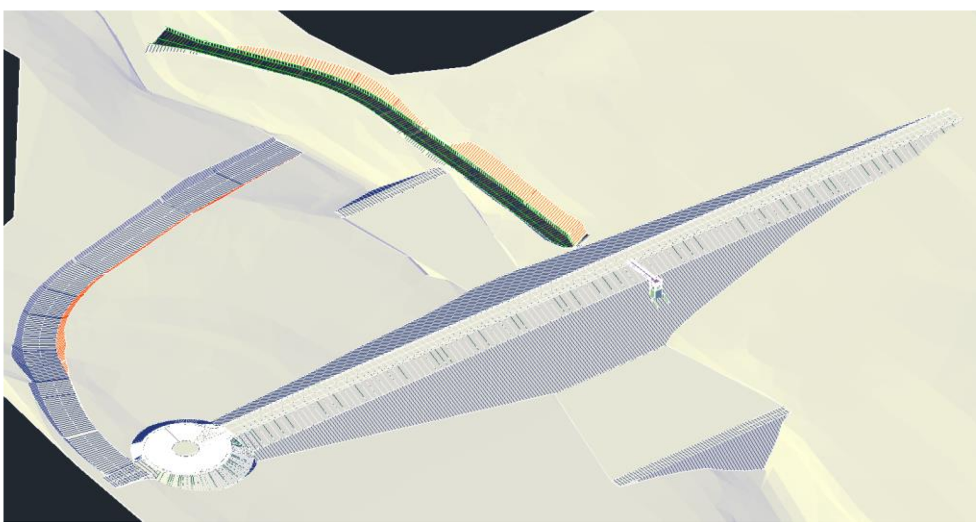


Figure 16 – Revit model inside Civil 3D

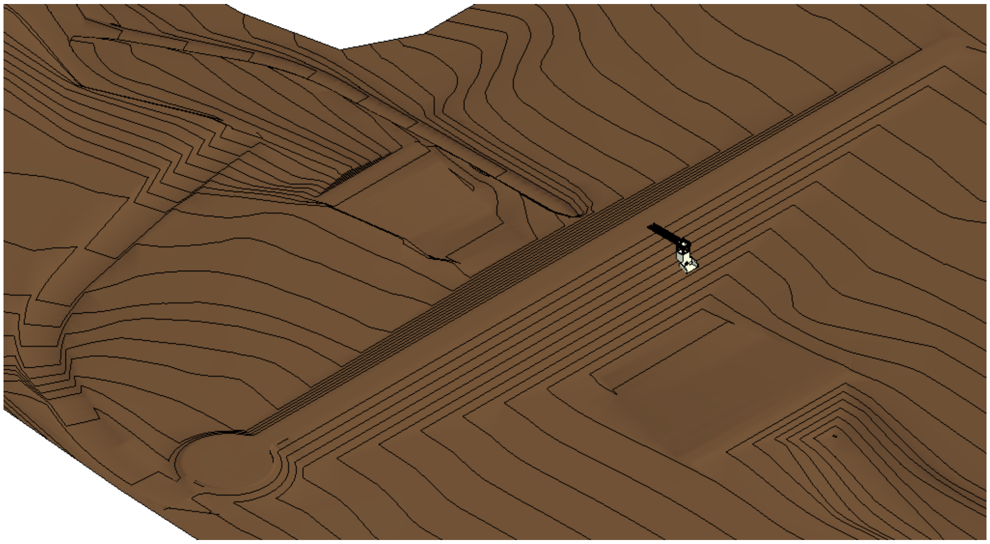


Figure 17 – Civil 3D surface inside Revit

After inserting the architecture model into the drainage model, a misalignment between the initial pipe and the inlet opening of the spillway structure was noticed, shown in the image below. Such a check allowed for the correction in the position of the pipes in relation to the spillway structure, by moving the Null Structure that makes the connection between pipes.

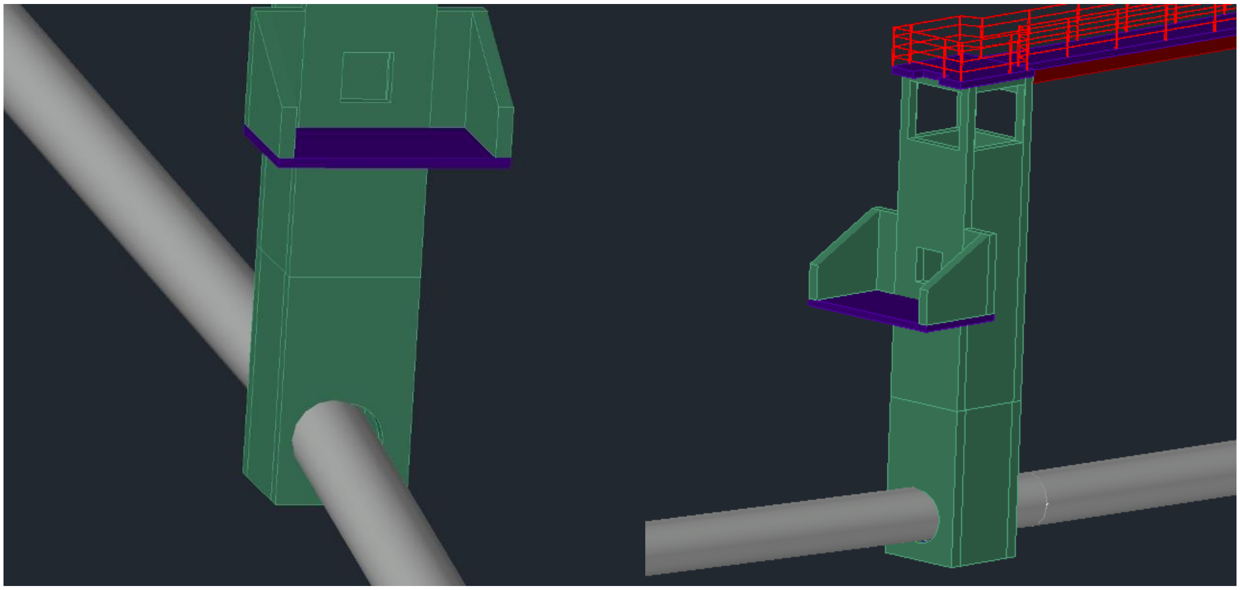


Figure 18 – Misalignment between spillway structure and pipes

Exported Products to Navisworks and InfoWorks ICM

Once the modeling and adjustments described above were completed, the interference checks between the disciplines were performed using Navisworks. From Civil 3D, was inserted the .dwg file, and from Revit, the .rvt file.

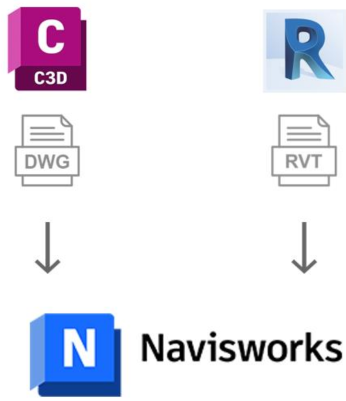


Figure 19 – Exported files from Civil 3D and Revit to Navisworks

Next, the "FINAL - TOPO" surface, the pipes and the spillway structure were exported to perform the simulations in InfoWorks ICM. To this end, the spillway structure was inserted in Civil 3D as a .dwg external reference. After that, the topography from Civil 3D was exported as LandXML (.xml), and pipes and spillway structures were exported as Shapefile (.shp) format.

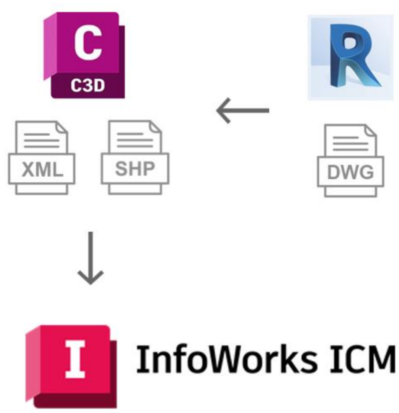


Figure 20 – Exported files from Civil 3D and Revit to InfoWorks ICM

Modeling Results

After performing the initial simulations and verifying the results in InfoWorks ICM, we proceeded to the executive designs. Regarding the 2D design, inconsistencies were verified in the extension of some slopes (cofferdams and channels, mainly), in the positioning of the beginning of the overflow pipe and in the position of the connection between pipes. Such verifications ensure fewer errors and rework in the construction phase, generating financial and time savings for the execution of the project.

Dam Simulation in InfoWorks ICM

Initial Steps

With the Autodesk Construction Cloud being the central location for data management and working with others on the team, shapefiles were brought into InfoWorks ICM for context, LandXMLs were used to develop surfaces, and Infraworks was used to supplement the LandXML surface to model a larger area. A 1D/2D model was built by importing the surface to InfoWorks ICM, drawing a 2D zone around the study area, and creating a mesh for the 2D portion of the analysis.

The dam itself was represented by a base linear structure object in InfoWorks ICM and the main outlet structure was represented by a pipe and sluice gate according to the dimensions in the plans provided. Inflow data was provided by other members of the team to run the simulations.

Figure 21 – InfoWorks ICM Model with Initial Background Information

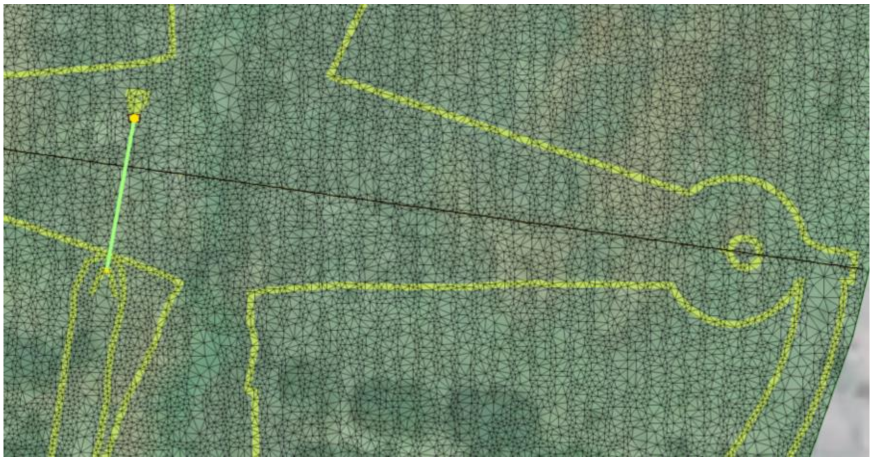


Figure 22 – InfoWorks ICM Model with Mesh and Structures

During periods with no significant rainfall, the dam operated normally with the amount of base flow entering the lake equaling the amount leaving through the outlet structure. For the dam break analysis, four different scenarios were built. The first two simulated the dam if it were to fail geotechnically when the water surface elevation in the lake reached a certain elevation. The difference between the two simulations in this case were that the dam would either fail completely or only a portion of the dam failed. The second two simulations were set up to have the dam fail once the water surface elevation overtopped the dam, again, fully and partially.

Figure 23 – Initial Conditions for the InfoWorks ICM Model

Using the design flow provided by the team, the dam only failed during the geotechnical failures since the water surface elevation could be set anywhere below the top of the dam. The design flow needed to be augmented in order to have the water surface elevation reach the top of the dam and therefore fail by overtopping. In all four simulations, there were no catastrophic impacts to any structures downstream from the dam.

Figure 24 – Maximum Inundation Area during Full Dam Failure when Overtopping

Visualization and Augmented Reality

Visualization

Navisworks was used in our workflow for three reasons:

- The first one was due to one of the main features that Navisworks provides, the clash detection. It was possible to find, for example, in the structural base of the spillway an interference with the spillway;
- The second was the union of solutions, with the base in the workflow presented before. Objects were modeled both in Civil 3D and in Revit, to coordinate the models it was necessary to use Navisworks;
- The third was because of the interoperability with Unity Solutions, in which reflect review works very well with rvt and nwd file extensions.

As dwg files were used in our flow, the conversion to nwd was necessary. Figure 25 shows the Navisworks interface.

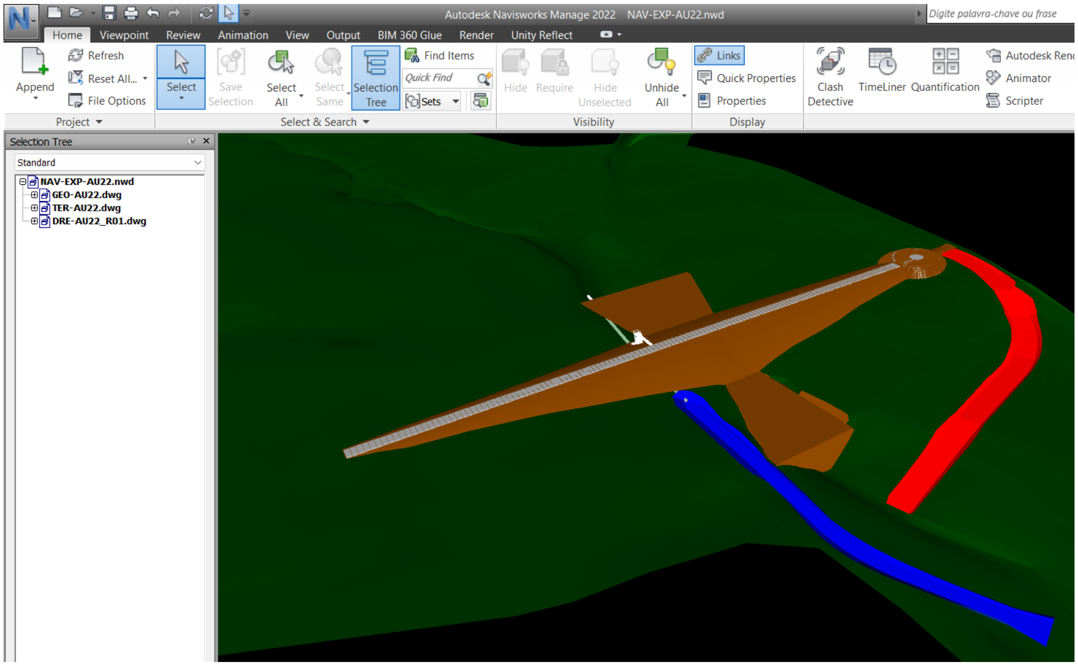


Figure 25 – Navisworks Interface

Augmented Reality

The choice to use Unity's reflect review was the icing on the cake of our project/design, to have a union between stakeholders and technical people.

The idea of a dam in augmented reality is that more than one person has access and visualization of the whole, it is to bring all the innovation and gamification to an engineering project. The choice between Autodesk and Unity was no accident. Unity, following the evolution of civil engineering, has seen more and more companies implementing the BIM methodology in their designs, thus improving their solutions so that they can be part of the process, adding value in the final part of the design, in the built, in the operation phase and maintenance.

The benefits from using Unity solutions are:

- It delivers a 3D model where the customer sees it from all angles, giving an experience that computes visualization alone cannot provide.
- Accessible: With a smartphone or any other device is possible to have an amazing experience, in other words, it is not necessary to have big investments in order to have an advanced technology experience.
- We know that BIM projects have much more than lines and polylines, but objects with information. With Unity solutions, the metadata of objects modeled in Autodesk solutions is maintained in this interoperability;

- When there is a visualization of the modeled object in the place where it will be built, it brings more security and confidence. This happens because in addition to checking for interference between objects, with augmented reality it is possible to see the real size of the object and how it will behave in the space it will be built.

And finally, in Figure 26 and Figure 27 is possible to see the benefit of the existing added value, different from any other way already existing in engineering.

Figure 26 – Overhead View of the Use of Reflect Review in Augmented Reality

Figure 27 – Reflect Review Interface

Results achieved

It became clear during the development of the project using the BIM methodology, that the effort to develop documentation, map the processes, standardize the deliverables, and plan the actions generated less time in the production of the dam project.

It was possible to find several inconsistencies in the old project, when starting the modeling of the new project using Autodesk Civil 3D, Revit and Navisworks suite of solutions.

Using the BIM documentation developed and previously agreed upon, making compatibility decisions was more agile, making the project more consistent and the analysis of results simpler.

Using Infoworks ICM gave us confidence that we were on the right track, as we were able to perform the most severe simulations to ensure the safety of this new dam. Moreover, quick and easy interoperability with Autodesk AEC Collection solutions resulted in less turnaround time than expected.

The possibilities of using Unity Reflect Review, from the design stage to asset management, are numerous and the ease of modeling in the most mature solutions on the market, such as Revit and Civil 3D. Importing into Navisworks for validation, and then importing to Unity Reflect Review for presentation make the flow very consistent and productive. We were extremely surprised by the future application possibilities of these solutions in augmented reality.

Next actions

Finally, we would like to demonstrate, in a new opportunity, the evolution of this work. In it, we expect to demonstrate the use of Autodesk ecosystem solutions for the underground infrastructure project of the city of Caarapó, such as:

- Drainage network;
- Sanitation network;
- Water supply network.

And the most important thing about this proposal is to validate the quality of a BIM project using Autodesk's design solutions to achieve interoperability with Innovyze Info360 Asset management solution, which is part of the Autodesk company.

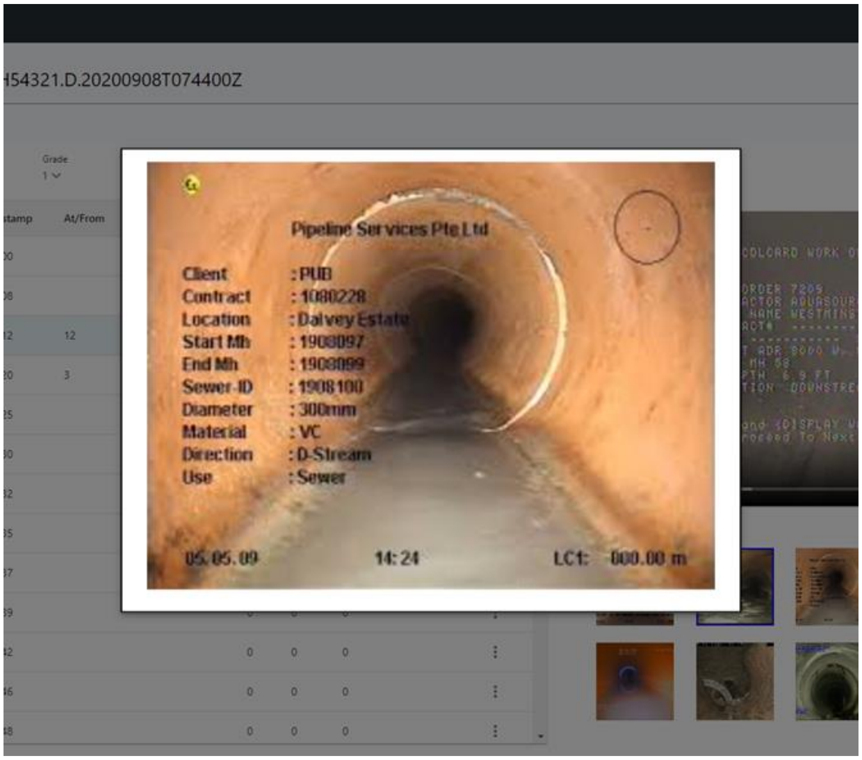


Figure 28 – Innovyze Info360 Asset