



GEORGE MUNICIPALITY

GWAING WWTW (PHASE A & B)

CONTRACT REF. 1752

STORMWATER MANAGEMENT PLAN REPORT NO. 1752-STW-01

12 DECEMBER 2025

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ACRONYMS

LCE	Lukhozi Consulting Engineers (Pty) Ltd
PCSWMM	Personal Computer Storm Water Management Model, an advanced modelling software package by Computational Hydraulics International (CHI)
SDF	Spatial Development Framework
EHES	<u>E</u> xisting <u>H</u> ydrology, <u>E</u> xisting <u>S</u> ystem (PCSWMM model naming convention)
FHFS	<u>F</u> uture <u>H</u> ydrology, <u>F</u> uture <u>S</u> ystem (PCSWMM model naming convention)
SCS-SA	Soil Conservation Services-South Africa, a deterministic peak flow and peak flow volume method.
m/s	Meters per second
m ³ /s	Cubic meters per second
m ²	Square meters
m ³	Cubic Meters
BBF	Biosolids Beneficiation Facility

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1 INTRODUCTION

1.1 BACKGROUND

The Gwaing Wastewater Treatment works (Gwaing WWTW) is one of the two major wastewater treatment works in George, Western Cape. Minor upgrades were recently completed, and the plant now has a total average dry weather flow (ADWF) capacity of 8.6 MLD when operating a UCT process at a design COD concentration of 782 mgCOD/l. The plant currently receives an ADWF of 10.7 MLD per day. The plant is operating over capacity. In addition, the population growth rate in George makes the extension of the wastewater treatment works a priority.

It is George Municipality's objective to upgrade the Gwaing WWTW and for the upgrade to comply with all current and relevant South African codes and standards. George Municipality appointed Lukhozi Consulting Engineers (Pty) Ltd (LCE) to provide professional engineering services necessary to implement the upgrade of the Gwaing WWTW to 21 MLD capacity. The first work package entailed the completion of a Master Plan that will serve as a guiding document for all current and future upgrades to Gwaing WWTW. This Concept Design Report describes the proposed design to achieve the required capacity of 21 MLD; however the Master Plan also provides a long-term solution to reach / achieve the ultimate capacity of 50ML per day.

1.2 PURPOSE OF REPORT

It is required as part of the environmental process that a Stormwater Management Plan (SWMP) shall be required as part of the Environmental Impact Assessment (EIA).

This report shall therefore constitute the SWMP for the Gwaing WWTW.

1.3 REFERENCE FOR DESIGN CRITERIA & STANDARDS

George Municipality does not have a stormwater by-law to address water quantity or quality. Therefore, for this assessment, the following guidelines shall be utilised:

- Section L, Stormwater, of the "The Neighbourhood Planning and Design Guide" (The DHS Red Book), compiled by the South African Department of Human Settlements (2019).

2 **BACKGROUND INFORMATION**

2.1 **SITE LOCALITY**

The Gwaing Wastewater Treatment Works falls under the jurisdiction of the George Municipality, situated in the Garden Route District within the Western Cape Province.

Figure 1 below indicates the position of the Gwaing WWTW in relation to George.

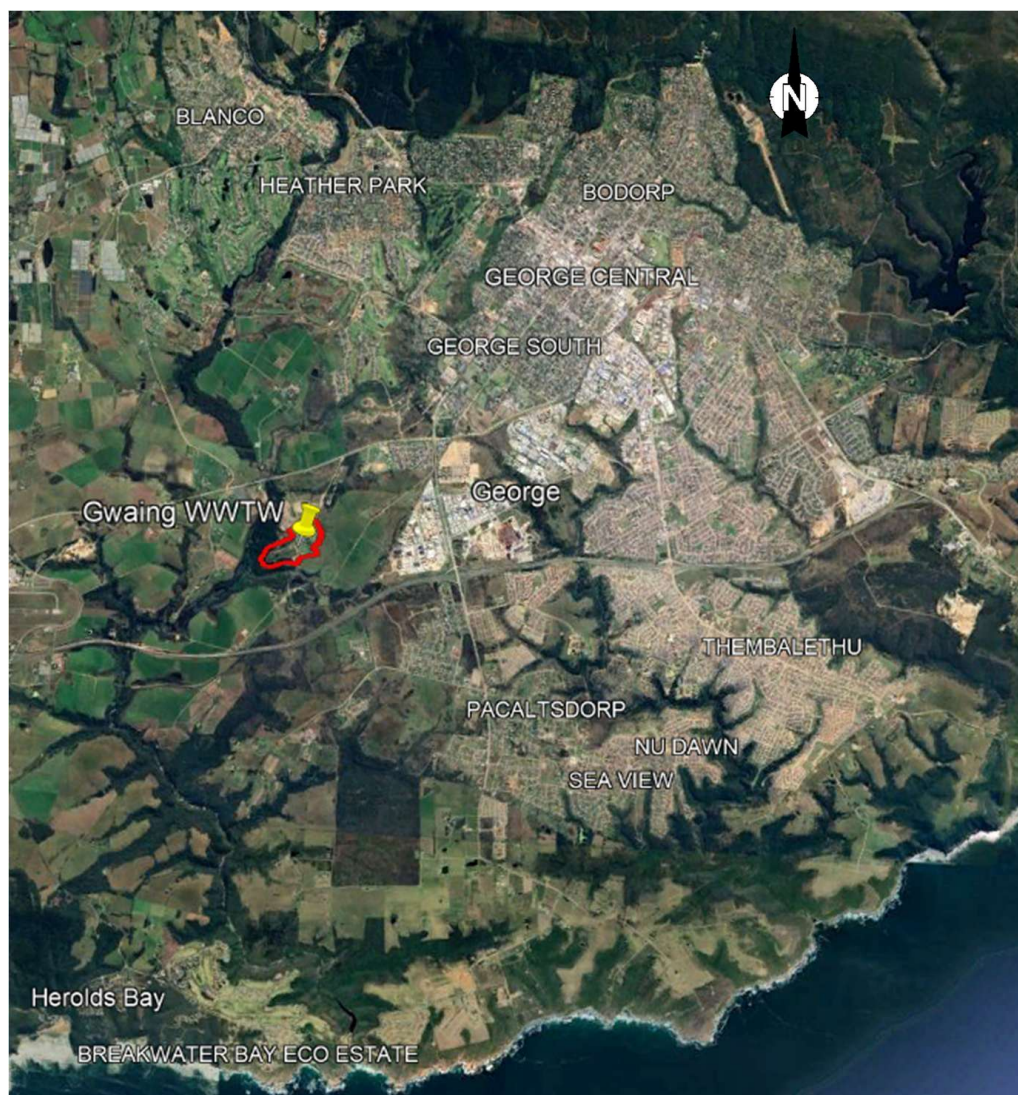


Figure 1: Gwaing WWTW Location (Google Earth)

The proposed upgrades and refurbishments, as defined in the Sewer Master Plan are contained within the site boundary of the wastewater treatment works. The site boundary and aerial image of the existing infrastructure at Gwaing WWTW are shown in **Figure 2** below:



Figure 2: Site Boundary and Existing Infrastructure (Google Earth Image taken February 2023)

2.2 SITE TOPOGRAPHY

The WWTW can be described as “flat” (<3%) to “soft-to-moderate” (3% to 10%), with slopes ranging from approximately 2% to 4%.

2.3 EXISTING SERVICES

The existing topographical survey indicated:

- Limited minor pipeline stormwater drainage systems.
- Sewer lines.
- Electrical cables.
- Unknown conduits.

From a modelling perspective, the existing stormwater pipelines are not considered significant and have not been assessed from a capacity perspective. The major overland drainage system has been utilised to determine drainage lines.

2.4 SOIL AND GEOHYDROLOGICAL CONDITIONS

2.4.1 Geological Assessment

The following summary of the soil and geohydrological conditions, as extracted from the Concept and Feasibility Design (Rev 3) report, are presented below:

Terra Geotechnical conducted a geotechnical investigation for the Gwaing WWTW upgrades. As part of the investigation 14 test pits were excavated (see **Figure 3**) and supported with 27 DPSH tests around the site.



Figure 3: Trial Pit Locations

The geotechnical report as included in the Concept Design Report (2025) presented several key findings which are presented below:

1. Transported Material Removal: Due to the variable and organic nature of the upper transported material across the site, it is recommended to remove it to a depth of at least 300 mm beyond the perimeter of the proposed developments. Variations in this depth should be assessed during planned earthworks.
2. Heave and Consolidation: The soils covering the site may experience heave and/or consolidation (volume loss and gain) under loading or when saturated. Adequate strengthening of structures is necessary to prevent structural damage due to differential settlement beneath foundations.
3. Moisture-Induced Differential Movements: Differential movements will be exaggerated due to heave and shrinkage when moisture conditions change beneath structures.
4. Foundation Recommendations:
 - a. For single- and double-storey structures, reinforced concrete strip/pad foundations are recommended.
 - b. The foundation medium should achieve a minimum of 95% Mod AASHTO density or less than 20 mm penetration per blow of a Dynamic Cone Penetrometer (DCP).
 - c. A recommended founding depth of 1 meter below the natural ground level (NGL) or below the transported soils ensures stability.
 - d. Bearing pressures should not exceed 150 kPa to limit settlement.
 - e. For heavier structures, consider deeper foundations (to weathered granite) or introduce imported structural fill.
 - f. Light reinforced concrete rafts may also be suitable.
5. Erodibility of Material: The granitic soils encountered across the site are prone to erosion.
6. Dispersive Soils: Backfill should match the compaction of surrounding soil to avoid up-slope groundwater diversion and tunnel erosion.
7. Slope Stability and Temporary Cuttings:
 - a. In general safe battering to 45° is proposed as a safe cut-back for deep excavations.
 - b. Long-term stability decreases due to reduced cohesion and increased friction (safe cut slopes as low as 25°).
 - c. Reworked residual granite remains stable if dry but can slump when subjected to standing water.
8. Dewatering Measures: Implement dewatering measures for open unsupported excavations prone to flooding. Safety precautions are crucial for excavations deeper than 1.5 meters.
9. Groundwater Occurrence: Perched groundwater seepage was observed across the site, generally with slow to moderate flow. Ferruginous material indicates seasonal fluctuating groundwater or excessive soil moisture movement.

2.4.2 Stormwater Geological Modelling

The following can be extrapolated from the geotechnical assessment from a hydrodynamic modelling and associated stormwater system design perspective:

- Granitic soils were encountered throughout the site, and are prone to erosion.
- Dewatering for excavations deeper than 1.5m, with a perched groundwater table being observed, indicates that minimal infiltration is likely to occur during a storm event and that significant portion of the rainfall shall be conveyed via surface runoff can be expected.

The infiltration parameters applied for hydrodynamic modelling are further described under **Section 3.2.1h)**. Cognisance of the limited infiltration shall be accounted for; and should the regional SCS-SA Soils Mapping (which shall be described in further detail under **Section 3.2.1h)**) indicate relatively free-draining soils, a more conservative approach shall be applied.

2.5 EXTERNAL CONTRIBUTING CATCHMENTS

The Gwaing WWTW is located adjacent to the confluence of the Gwaing River and a small tributary. There is a proposed commercial / industrial development proposed to the east of the WWTW within Groeneweid Park.

For this study:

- The hydrology and associated peak flows for the Gwaing River and its tributary has not been estimated. Floodlines were not available for this study, however it is assumed that the original WWTW design would have been constructed above and outside of at least the 100-year return period flood levels and associated floodlines. The proposed upgrades are all set back from the watercourses, and shall not be impacted on by the existing floodlines.
- It is assumed that the proposed commercial / industrial development shall both provide its own attenuation to reduce peak flows to pre-development levels; and that the existing flow regime which currently bypasses the WWTW will continue to bypass the WWTW post-construction (i.e. the WWTW shall not receive any additional peak flows from the proposed development and that the proposed stormwater drainage systems for the WWTW are not required to be designed to include external catchment inflows.

2.6 PROPOSED WWTW LAYOUT AND PHASING

The proposed layout of the WWTW is presented in **Figure 4**.

It is noted that the various measures proposed are to be phased; from a stormwater drainage perspective the ultimate scenario stormwater drainage system shall be assessed hydrodynamically.

Important Note

From a construction perspective, the stormwater drainage system shall be constructed to serve the ultimate scenario regardless of phasing.

This may require additional monitoring and maintenance / cleaning of the new infrastructure for the initial phases, as less runoff and associated peak flows shall impact on associated peak flow velocities and self-cleansing velocities might not be met. Increased siltation from the erodible granites may therefore occur.



Figure 4: Proposed WWTW Layout

It is important to note the following:

- The proposed Biosolids Beneficiation Facility (BBF) is located outside of the WWTW erf boundary. Erven within the adjacent Groeneweid Park commercial / industrial development have been set aside for the construction of the BBF. The Groeneweid Park commercial / industrial development in relation to the Gwaing WWTW is shown on **Figure 5** and the erven proposed to site the BBF is shown on **Figure 6**.

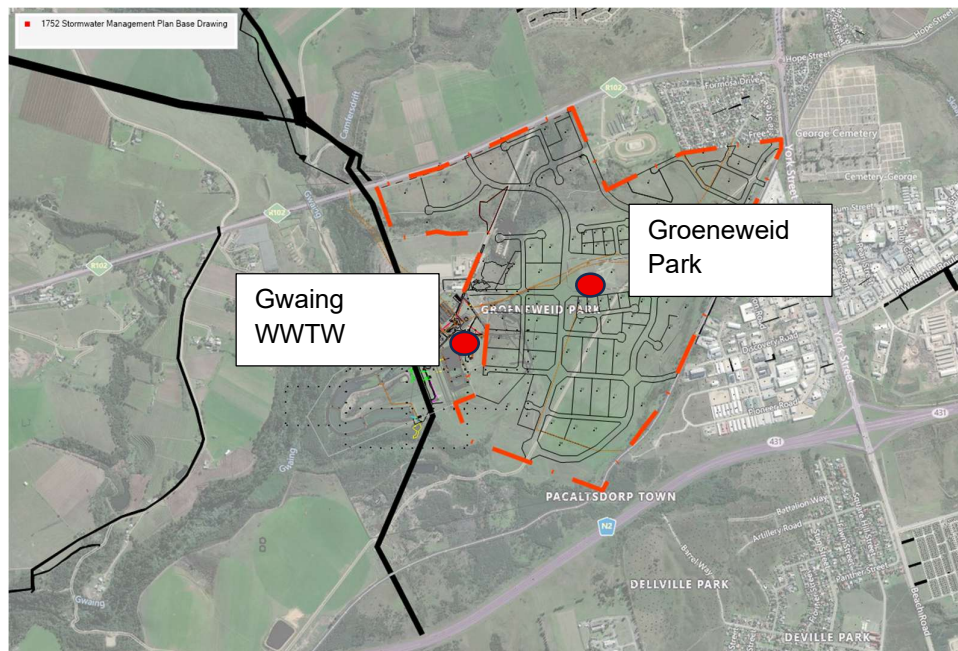


Figure 5: Proposed Groeneweid Park Commercial / Industrial Development

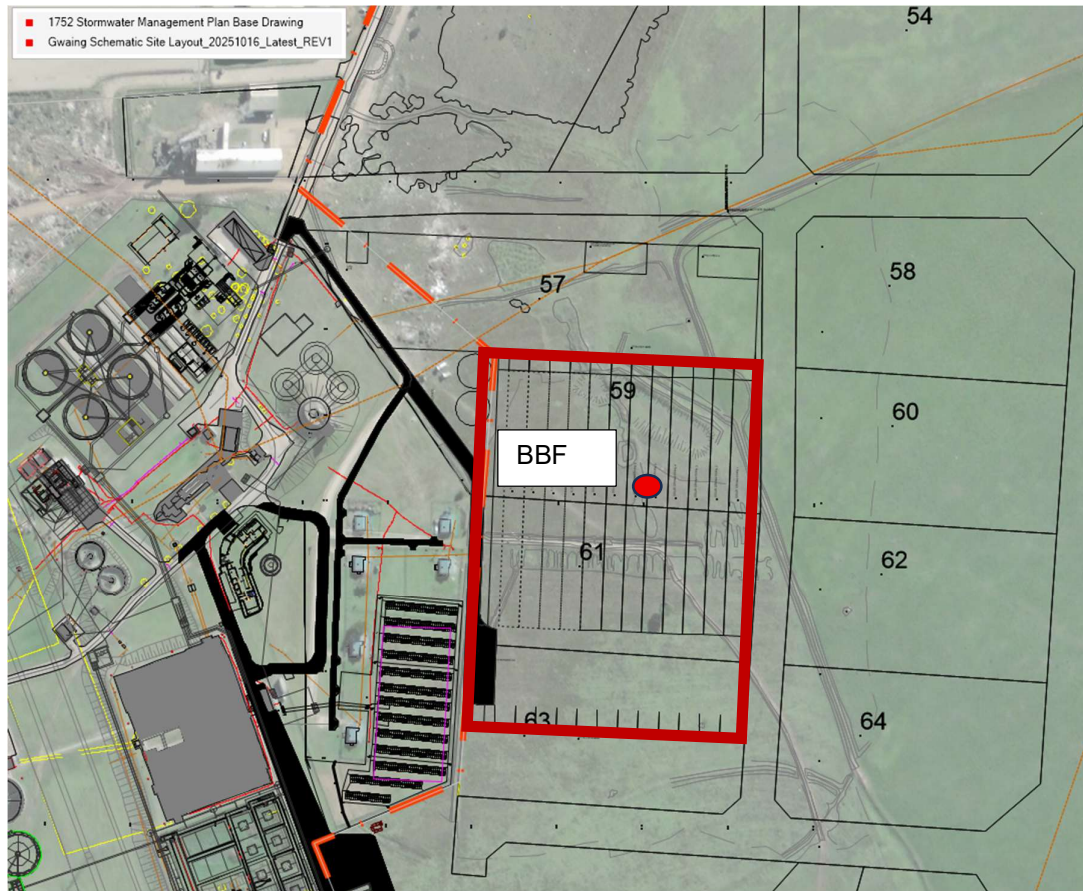


Figure 6: Location of the Proposed BBF (Erven 57, 59, 61 and 63)

The phasing is described in further detail below. For a detailed description of the WWTW infrastructure, refer to the Preliminary and Design Report REV 3 (2025).

Phase A

- 2 additional SSTs for Module A
- 4 SSTs for Module B (can operate with Reactor A)
- New RAS Pumpstation
- New Substation building
- Replacement of the DN450 with a DN950 pipe from the existing chlorine contact channel to the river outlet.
- Electrical Equipment
- Associated road and stormwater infrastructure

Phase B

- New Inlet Works Train 1
- Regional Grit and Screenings Facility (Construction may be in a later phase or on a separate contract depending on funding availability)
- New biological reactor (Module B)
- New Blower House and aeration system
- Service corridor for air header

- New WAS pumpstation
- New UV disinfection system (Subject to approval by George Municipality)
- Extension to WAS Dewatering Facility
- New Process Control including Admin Building (Construction of Admin Building may be in a later phase or on a separate contract depending on funding availability)
- Electrical Equipment
- Potentially sludge storage bunds and/or sludge drying facility
- Demolition of sludge drying beds
- Associated roads and stormwater infrastructure

Phase C

- 1 New biological reactor (Module C)
- Extension of Blower House and aeration system
- 4 new SSTs (Module C)
- Additional UV banks (M&E) (If approved by George Municipality)
- New Inlet Works Train 2
- Additional DN950 outlet pipe from existing chlorine contact channel to the river outlet
- Electrical Equipment
- Associated roads and stormwater infrastructure

Phase D

- 4 New PSTs
- Primary Sludge Pump Station
- 2 Gravity Thickeners (repurpose old PSTs)
- 4 Anaerobic Digesters
- Primary Sludge Dewatering Facility
- Electrical Equipment
- Associated roads and stormwater infrastructure

Biosolids Beneficiation Facility (BBF)

- Guard House
- Perimeter fencing and access gate
- Approximately 30 000 m² of concrete slabs for the various stages of sludge stockpiling, solar drying, composting and sludge handling. This includes the areas under translucent roof sheeting for solar drying.
- Approximately 13 000 m² in plan view of translucent roof sheeting ('greenhouse') structures.
- One 18m x 36m shed with a clear height of 4.5m and without any columns inside the building for the sludge granulation plant.
- A second building of similar footprint for the packaging plant and distribution depot. This building is to include offices, ablution and a canteen for the operating staff of approximately 6 people.
- Movable precast concrete walls placed on slabs to demarcate separated process areas and to prevent contamination of treated sludge by raw sludge.
- Access Roads
- Rainwater collection and storage from all roof structures
- Stormwater collection and drainage from concrete slabs with pipeline to Gwaing WWTW inlet works.

3 **HYDROLOGICAL AND HYDRAULIC STORMWATER MODELLING METHODOLOGY**

3.1 **COMPILATION APPROACH**

The feasibility is based on the available town planning, land uses and detailed features, including the required upgrades to the immediate existing system. The approach and methodology for the compilation of this SWMP are as per **Table 1** below.

Table 1: SWMP Compilation Approach and Methodology

Task Sequence	Task	Aspect
1	Data Collation	Collate “as-built” stormwater drainage system plans for catchment area
		Collate cadastral and topographical mapping
		Collate previous reports
2	Stormwater Run-off Characteristics and Factors	Define and delineate the catchment boundary of the drainage system
		Rainfall data
		Analyse and assess present and future land-use planning
3	Stormwater Management Planning	Selection of analysis and design standards
		Catchment hydrological and drainage system hydraulic modelling.
		Conceptual design of the proposed detention pond
4	Reporting	Compilation of feasibility report

3.1.1 **Modelling Software and Models Compiled**

Models of the existing and future stormwater drainage systems were compiled using the PCSWMM hydrological and hydraulic modelling software developed by Computational Hydraulics International (CHI) based on the US EPA SWMM software. These models were developed to assess the impacts of future land-use development, as well as for the conceptual design of remedial measures.

The relevant models compiled for this study are given in **Table 2**.

Table 2: Compiled Models

Model Reference	Model Description	Return Periods Assessed	Model Purpose	Model Basis
1	EHES (Existing Hydrology, Existing System)	10-year 50-year 100-year	To assess the existing stormwater drainage systems serving the WWTW.	Existing stormwater and WWTW infrastructure layouts
2	FHFVS (Future Hydrology, Future System)	10-year 50-year 100-year	To design the proposed stormwater drainage systems to serve the WWTW	Based on the FHES Model

3.2 DELINEATION AND MAPPING OF EXISTING STORMWATER DRAINAGE SYSTEMS

3.2.1 Existing and Future Scenario Hydrologic Modelling

The PCSWMM hydrologic component has numerous variables which describe the sub-catchment:

- Rainfall
- Catchment Area
- Flow Length and Width
- Catchment Slope
- Impervious Percentages
- Roughness (N Imperv and N Perv)
- D-Store Impervious and D-Store Pervious
- Sub-Area Routing and Percent Routed

a) Storm Rainfall

The “Design Rainfall Estimation” Version 3 (2012) package as developed by Smithers and Schulze, as part of the Water Research Commission project titled "Rainfall Statistics for Design Flood Estimation in South Africa" (WRC Project K5/1060) was utilised to estimate the required 1-day, 24-hour and point rainfall depths.

The following 24-hour rainfall depths were applied for PCSWMM hydrologic modelling:

- 2-year - 75 mm
- 5-year - 111 mm
- 10-year - 139 mm
- 20-year - 171 mm
- 50-year - 218 mm
- 100-year - 259 mm

The SCS-SA Type 2 rainfall distribution was applied to each sub-catchment as 24-hour rainfall depth, with each return period modelled as a separate gauge.

A 24-hour storm duration was used in all instances as per the SCS-SA methodology (WRC TT 31/87, 1987).

b) Catchment Area

The sub-catchment areas were automatically calculated within the PCSWMM 2024 software for the sub-catchments delineated.

c) Catchment Length and Width

The catchment width is defined as the characteristic width of the overland flow path for sheet flow runoff. The width is estimated by dividing the sub-catchment area by the average maximum overland flow length. This defines whether the catchment is long and thin or short and wide, which will produce either longer or shorter response times.

The catchment length was adjusted as part of the verification process to produce reasonable hydrographs as part of this study to align with the Rational Method and SCS-SA method peak flow and volume estimates.

d) Catchment Slope

The slopes were estimated by interrogating the LiDAR DEM and ranges from approximately 2% to 4%. For modelling purposes, an average slope of 2.5% was applied to all catchments.

e) Impervious Percentages

Impervious area is defined as those surfaces of the landscape that do not allow direct infiltration into the soil (e.g., rooftops, pavement, driveways, etc.). For the purposes of this study, the percentage impervious areas are based on the existing and proposed WWTW works layout, with:

- All WWTW infrastructure including buildings, roads, ponds etc. have been assumed to be 100% impervious (i.e. no infiltration shall occur).
- Open spaces shall be assessed as 0% impervious. Where predominately open space with comparatively small infrastructure located within the catchment (e.g. workers' housing), an allowance of between 5% and 10% for this hardening has been included.

f) Roughness Coefficients

The Manning coefficient of roughness (n) is an empirically derived coefficient, as applied in the Manning formula. The coefficient is determined by the type of surface over which the runoff flows, and the associated resistance the surface provides to storm runoff.

The Manning coefficient used for overland flow are tabulated in **Table 3** below:

Table 3: Typical Manning Roughness Coefficient

Land-use	Manning's 'n' value
Impervious areas	0.018
Pervious areas	0.025 – 0.06

g) Depression Storage

Depression storage is an estimate of the volume that must be filled prior to the occurrence of runoff from both pervious and impervious areas. It represents a loss or “initial abstraction” caused by such phenomena as surface ponding, surface wetting, interception and evaporation.

Typical depression storage values are given in **Table 4** below:

Table 4: Typical Depression Storage Values

Runoff Surface	Typical Depression Storage Depths (mm)
Impervious	2 mm
Pervious	5 mm

h) Infiltration

Infiltration is the applicable portion of a sub-catchment where precipitation infiltrates in the permeable soils. Many factors influence infiltration, but it is primarily affected by the soils in the sub-catchment area.

The following values were applied to the sub-catchments based on the hydrological soils group applicable in the Horton method of infiltration estimation as given in **Table 5**.

Table 5: Horton Infiltration Rates based on Hydrological Soils Groups

Hydrological Soils Group	Maximum Infiltration Rate (mm/hr)	Minimum Infiltration Rate (mm/hr)	Decay Constant (1/hour)	Drying Time (days)	Maximum Infiltration Volume (mm)
A	25	11.45	2	14	0
A/B	19	8.6	3	10	0
B	13	5.7	5	7	0
B/C	9.5	4.2	6	4	0
C	6	2.54	7	2	0
C/D	4.5	1.6	7	2	0
D	3	0.64	7	2	0

The soil types are in accordance with the SCS soil categories and are defined as follows:

- A - Well-drained sand and gravel; high permeability
- B - Moderate to well-drained; moderately fine to moderately coarse textured; moderately permeable
- C - Poor to moderately well-drained; moderately fine to fine textured; slow permeability
- D - Poorly drained, clay soils with high swelling point, permanent high-water table, claypan, or shallow soils over nearly impervious layer(s)

For South Africa, Smithers and Schulze recommended further discretisation with additional sub-groups (i.e. A/B, B/C, C/D).

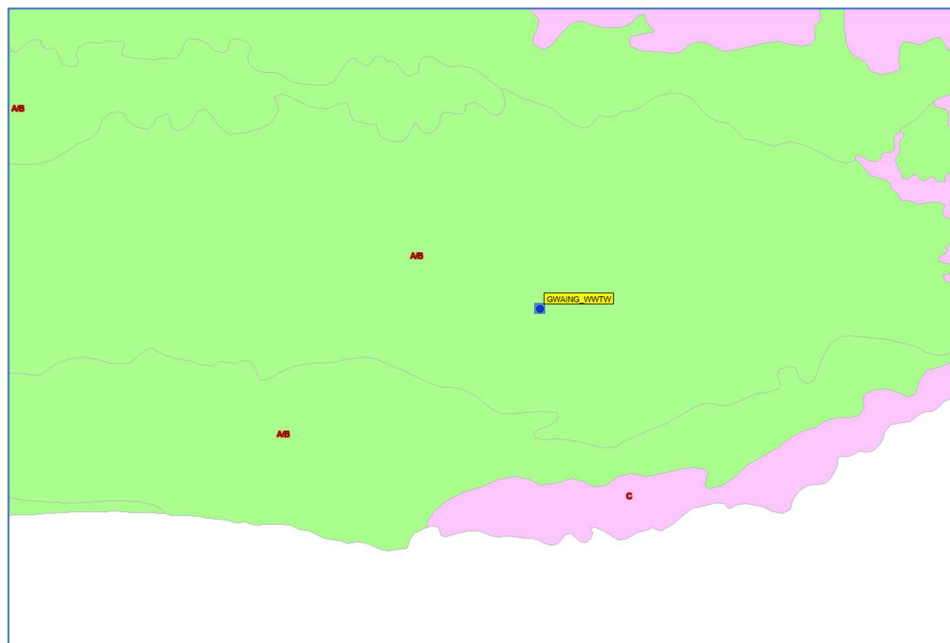


Figure 7: SCS-SA Soils Grouping

Gwaing WWTW is located within the A/B soils grouping, which has a high infiltration potential. However, the geotechnical assessment indicated a perched water table. Therefore, for this assessment, the Soils Grouping of B/C has been chosen to represent the soils. Type B/C soils have relatively low infiltration material. It should be noted that the soils grouping shall:

- Only have a significant impact on those areas that have a significantly pervious percentage (i.e. natural areas). The WWTW infrastructure (ponds, roads and buildings) have been assessed at 100% impervious, which shall not allow infiltration to occur.
- Have more of an impact on the more regular storm events. The major stormwater drainage systems which shall be assessed for this SWMP shall be based on the major storm events, namely the 50-year and 100-year return periods, where saturation shall occur early on and the majority of rainfall shall run off in any event.

The PCSWMM modelling assumes Antecedent Moisture Conditions (AMC) as dry (AMCII), which shall result in the soils being able to initially infiltrate runoff and thereby reducing runoff. The impact of a likely perched water table is already accounted for in the SCS-SA Soils Grouping and no further adjustment for AMC is therefore required.

3.2.2 Existing and Future Scenario Drainage System Components and Hydraulic Parameters

The definition of the drainage system components and the hydraulic parameters included in the PCSWMM models are described in this section. Various assumptions were necessary in order to compile the hydraulic component of the PCSWMM models and to ensure the realistic modelling of the drainage system.

a) Nodes

Nodes represent the following hydraulic structures/functions:

- Manhole – can also represent changes in the stormwater network (e.g., changes in conduit dimensions, slope, direction, etc.). Data required is invert and ground levels.
- Outfall – defines the outfall boundary conditions. The condition can either be free, normal, fixed, tidal or based on a time series.
- Storage – defines the hydraulic properties of the storage structure/element. Data required are the stage–storage area relationship, the invert level and the maximum storage level. This applies to both formal as well as informal storage and includes “trapped” low spots or sinks.

Levels were estimated as follows:

- For reaches of overland flow, the invert level was automatically estimated utilising the DEM and the automated functionality within PCSWMM. The Rim Elevation was estimated by adding 0.2m, which equates to the depth of the 0.2m rectangular section used to represent the reach.
- For the storages which were modelled to represent the four existing maturation ponds and the chlorine contact tank, the automated stage storage functionality within PCSWMM was utilised. The invert levels of the pipes serving the ponds were estimated based on the available “as-built” data, as the LiDAR indicates both some

siltation (Pond 1) and scour (Ponds 2, 3 and 4). The invert and rim elevations for the 1050mm diameter outlet pipe from Pond 4 to the chlorine contact tank and the 900mm diameter line from the chlorine contact tank to its outfall at the reinstated donga were based on the available “as-built” drawings.

b) Underground Conduits

The underground network was modelled using their size, length, upstream and downstream level offsets, and typical Manning’s roughness coefficient of 0.013, were used.

c) Overland Flow

Overland flow paths were presented by rectangular sections.

Typical road sections were applied to model the roads which shall be constructed with kerbing to provide conveyance capacity; and overland flow routes shall be modelled as rectangular open sections. Watercourses shall be modelled either as natural sections or as parabolic channels, as appropriate.

d) Weirs

Weirs were used to represent emergency spillways for the maturation ponds.

3.2.3 Existing and Future Scenario Model Simulation Parameters

The compiled model was simulated in PCSWMM using the “dynamic wave” flow routing method. This method implements the use of St Venant equations.

Other general runoff and routing control parameters and the values for the EHES and FHFS models are presented in **Table 6**:

Table 6: Model Simulation Parameters

Control	Parameter	Description	Value
Dates	Start analysis	Start of simulation M/D/Y : H:M:S	M/D/Y H:M:S
	Start reporting on	Start of reporting of simulation results	M/D/Y H:M:S
	End analysis	End of simulation M/D/Y : H:M:S	M/D/Y H:M:S
Time Step	Reporting	Time step for report generation	1 minute
	Runoff: Dry Weather	Updates infiltration parameters	1 seconds
	Runoff: Wet Weather	Computes runoff from sub- catchments during rainfall or when ponded water remains at the surface	1 seconds

Control	Parameter	Description	Value
	Routing	Time step for routing flows through the conveyance system	1 second
Dynamic Wave	Inertial terms	Indicates how the inertial terms are handled in the St Venant's equation. (Options: keep, dampen, ignore)	Keep
	Define super-critical flow by:	Selects the basis used to determine when supercritical flows occur in a conduit. (Options: Slope, Froude Number, both)	Both
	Force main equation	Selects which equation is used to determine frictional losses during pressurised flow. (Options: Hazen- Williams; Darcy-Weisbach)	Hazen-Williams

3.2.4 Peak Flow Determination and Verification

a) Existing Scenario Peak Flow Determination and Verification

No statistical/historical flood event data was available, therefore deterministic methods have been used for overall Existing Scenario catchment verification.

The verification has been carried out as follows:

- The catchment runoff (excluding routing) was verified against the Rational Method and the SCS-SA Method. Routing was excluded as:
 - The catchment is small and the impact of routing on the estimated peak flows shall be limited.
 - The maturation ponds located on the western boundary of the WWTW receive significant runoff and have been modelled as storage nodes. This shall therefore reduce the runoff discharging downstream, therefore making it impractical to compare the estimated attenuated peak flows at the outlet with the unattenuated peak flows estimated by the Rational Method and SCS-SA Method.

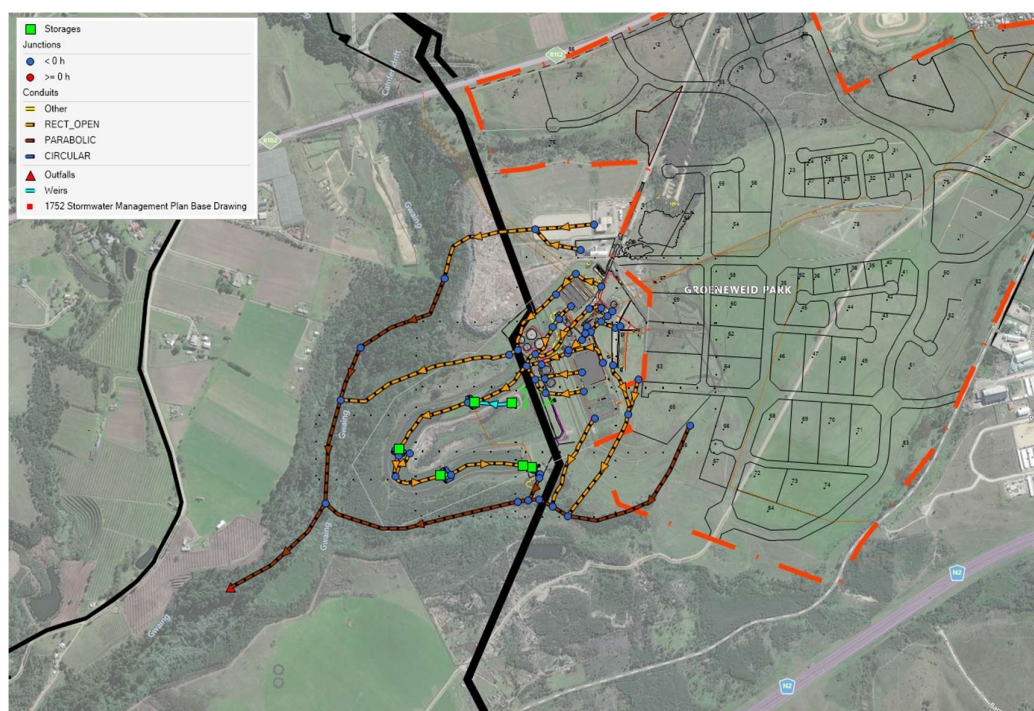


Figure 8: EHES PCSWMM Model Layout

Peak flows for the existing land-use scenario were verified against a number of recognized runoff methods and associated software, namely:

- Rational Method – a deterministic method which expresses a relationship between rainfall intensity and catchment area as independent variables and the peak flood discharge resulting from the rainfall as the dependent variable.
- SCS-SA Method– a deterministic method that is applicable to catchments of up to 30km².

The comparison for the 2-year to the 100-year return period yielded the following results and are presented in **Table 7** and the peak flows presented graphically on **Figure 9**.

Table 7: EHES Model Verification - Peak Flows

Return Period	Rational Method Peak flow (m ³ /s)	SCS-SA Method Peak flow (m ³ /s)	PCSWMM Peak Flow (m ³ /s)
2-year	3.95	2.40	2.27
5-year	5.86	5.20	4.72
10-year	7.32	7.30	7.03
20-year	9.89	10.60	10.01
50-year	13.74	15.40	15.04
100-year	15.64	25.00	19.80

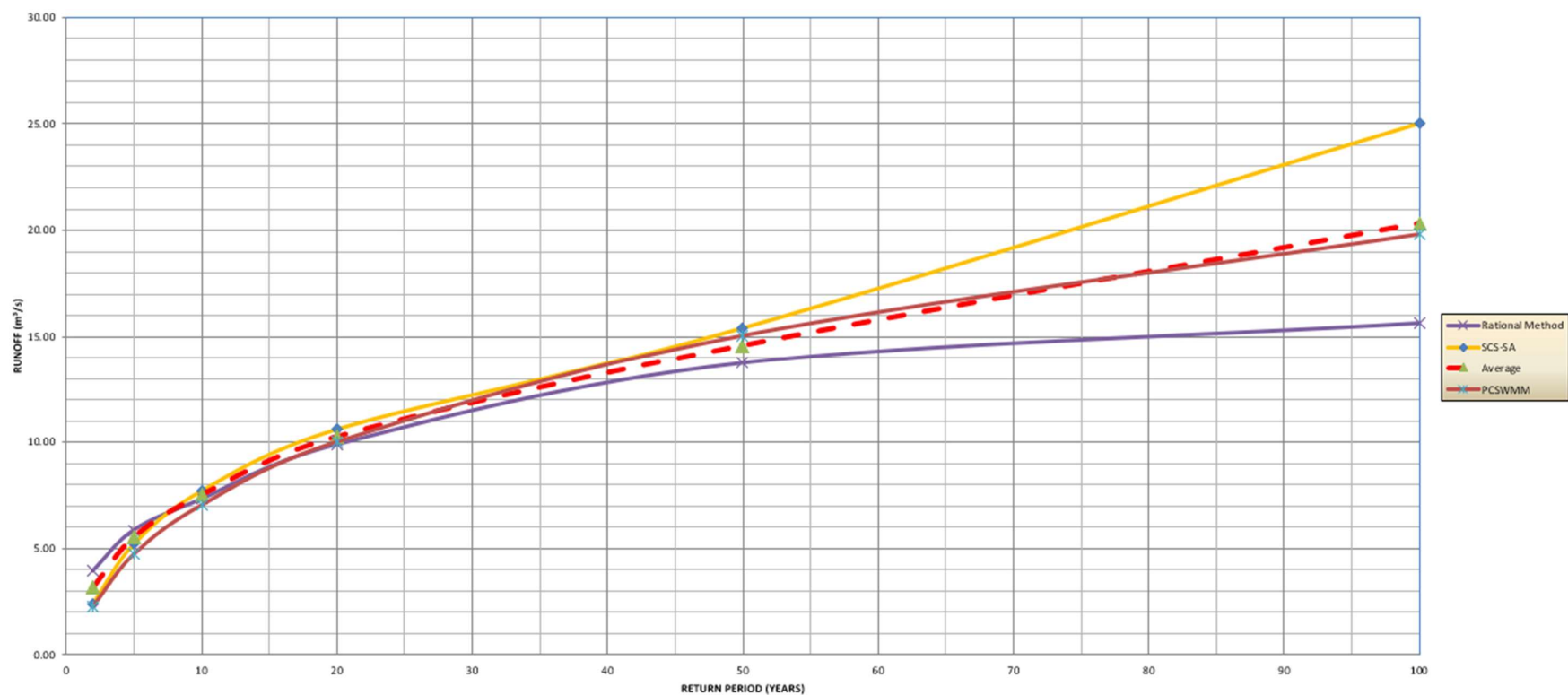


Figure 9: EHES Hydrological Verification (Graphical Representation)

In addition, the SCS-SA runoff volumes were compared for the two contributing catchments:

- SCS-SA estimates 142.5 ML, and PCSWMM estimates 149.88 ML

It can be seen that from the 2-year to the 50-year return periods, the peak flows for the three methods have a good correlation, with the 100-year SCS-SA estimating noticeably higher than the Rational Method and the PCSWMM hydrodynamic model. The overall correlation is considered acceptable, and the PCSWMM hydrodynamic model has therefore been applied for the modelling and assessment of the existing and proposed future stormwater drainage systems.

b) Future Scenario Peak Flow Determination and Verification

The methodology as employed for the EHES model was utilised to verify the future scenario. The catchments and impervious areas were adjusted to reflect the future WWTW for the ultimate 50ML/day WWTW capacity.

The comparison for the 2-year to the 100-year return period yielded the following results and are presented in **Table 8** and presented graphically on **Figure 10**.

Table 8: FHFS Model Verification - Peak Flows

Return Period	Rational Method Peak flow (m ³ /s)	SCS-SA Method Peak flow (m ³ /s)	PCSWMM Peak Flow (m ³ /s)
2-year	4.30	2.80	2.46
5-year	6.37	5.90	5.05
10-year	7.96	8.60	7.49
20-year	10.76	11.70	10.67
50-year	14.96	16.70	15.81
100-year	17.02	26.60	20.79

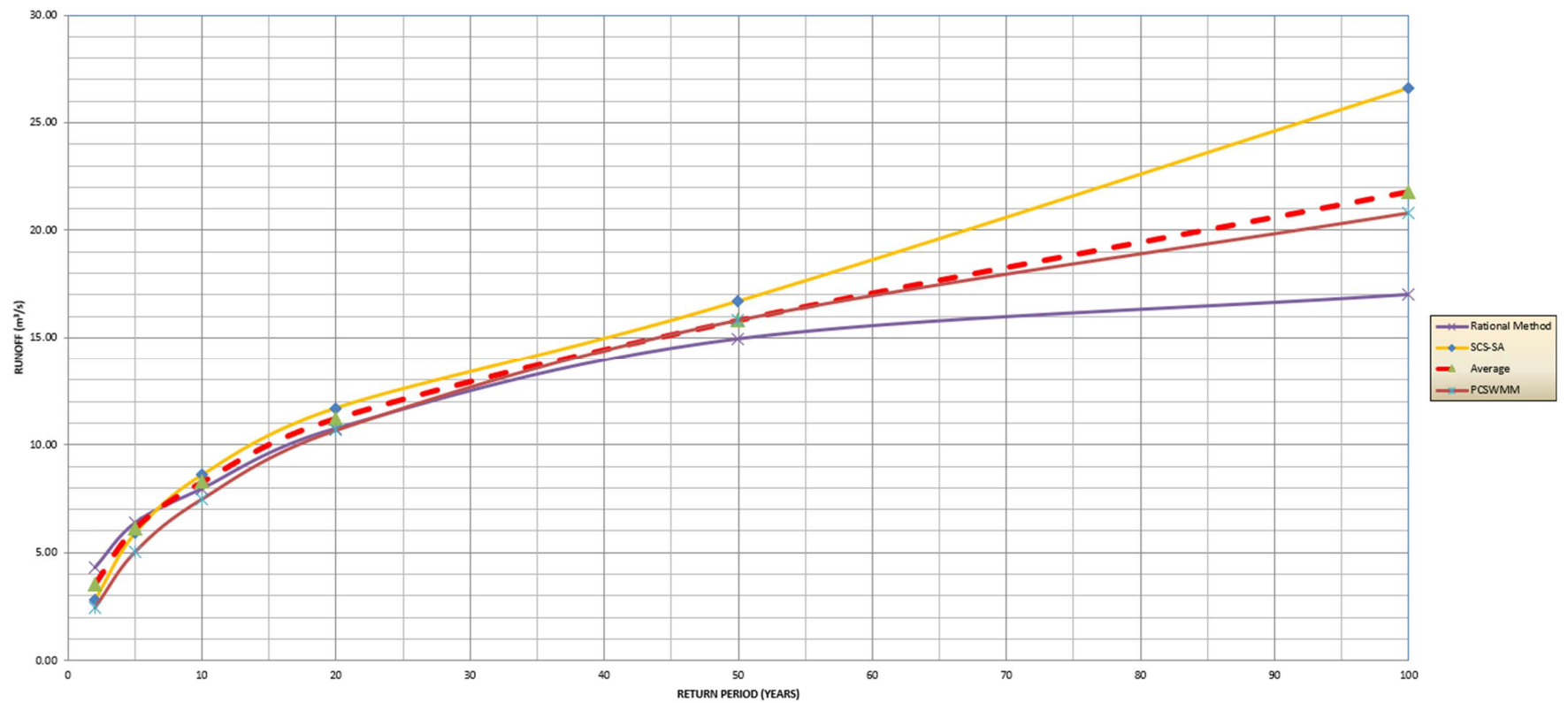


Figure 10: FHFS Hydrological Verification (Graphical Presentation)

In addition, the SCS-SA runoff volumes were compared for the two contributing catchments:

- SCS-SA estimates 151.7 ML, and PCSWMM estimates 155.07 ML

It can be seen that from the 2-year to the 50-year return periods, the peak flows for the three methods have a good correlation, with the 100-year SCS-SA estimating noticeably higher than the Rational Method and the PCSWMM hydrodynamic model. The overall correlation is considered acceptable, and the PCSWMM hydrodynamic model has therefore been applied for the modelling and assessment of the existing and proposed future stormwater drainage systems.

Important Note

The peak flow estimation and verification was carried out for the WWTW and its contributing catchments only. The peak flows for the Gwaing River were not assessed as part of this study.

3.2.5 Sewerage Base Flows

Sewerage base flows have not been included in the model verification. However, the existing maturation ponds shall receive a portion of the existing wastewater base flows with the ponds receiving storm runoff during rainfall events.

The existing capacity of the WWTW is 10.7 ML per day, which equates to a base flow of 0.123 m³/s. The maturation ponds for the ultimate design scenario shall be able to treat a baseflow of 0.115 m³/s.

Therefore, base flows for the EHES (existing) and ultimate design scenarios have been incorporated as baseline flows within the most upstream junction serving the four maturation ponds. The pipelines which shall be designed to convey these base flows have not been modelled.

4 EXISTING ASSESSMENT METHODOLOGY AND RESULTS

No capacity assessments of the existing underground stormwater systems were carried out; neither were the overland flow paths which dominate the WWTW assessed for capacity. The EHES modelling has been compiled and assessed to determine the baseline scenario, and to determine the impact of the ultimate 50ML per day upgrades on the estimated peak flows and in particular the impact on the existing maturation ponds.

No results have therefore been presented in this section. Refer to **Section 5** (Future Drainage System Assessment Methodology and Results) for the comparison of existing and future development peak flows and volumes and the associated impact on the available capacities within the maturation ponds.

5 FUTURE DRAINAGE SYSTEM ASSESSMENT METHODOLOGY AND RESULTS

5.1 POLICY REQUIREMENTS

Section L, Stormwater, of the “The Neighbourhood Planning and Design Guide” (The DHS Red Book), compiled by the South African Department of Human Settlement (2019) addresses both water quality and quantity. Water quality, from a structural mitigation measure perspective, shall not be addressed as part of this study as:

- The proposed Biosolids Beneficiation Facility (BBF), which shall be discussed in further detail later in the report, shall be designed to return any runoff (which shall likely be contaminated) back to the WWTW for further treatment.
- Clean, direct runoff from the site (buildings, roads and WWTW elements) shall be retained within the maturation ponds as per environmental requirements. Therefore, runoff improvement is not required.

Therefore, only water quantity (conveyance and attenuation) shall be addressed as part of this study.

For the minor stormwater drainage system, general commercial and industrial is recommended to be designed for the 5-year return period; and high valued central business districts 5 to 10-years. Although a WWTW is not a business district, it is considered high value infrastructure, so minor stormwater drainage systems (if required), shall be designed for the 10-year return period.

For the major stormwater drainage system, the Red Book states that the minimum flood frequency for the design of the major stormwater drainage system is the 100-year return period.

The Red Book also recommends the following be considered:

- The Peak Maximum Flood (PMF) or Regional Maximum Flood (RMF) for vulnerable communities or where high hazard activities (e.g. Land fill, cemeteries, fuel storage etc. be constructed.
- The Red Book also presents design return periods from Australia; with a Utility Installation design return period of 200-years.

For this study, the 100-year return period has been chosen. The higher peak flows which would be estimated by the PMF / RMF and by applying the recommendation for a Utility Installation have not been considered as:

- The PMF and RMF is applicable for large catchments, not for catchments less than a square kilometre.
- Although the Rainfall Design Estimation package does include the 200-year return period, the rainfall records for the surrounding stations range from 29 years to 93 years. Therefore the statistical estimation of the 200-year return period design depth is a significant extrapolation from the available data. It is therefore considered overly conservative. It is considered highly unlikely that the catchment will receive 306 mm of rain in a 24-hour period, considering that the Mean Annual Precipitation for the site is estimated to be 702 mm. It is also noted that, for the City of Cape

Town which is a significantly larger metropolitan area and for which by-laws are published, the maximum design return period is the 100-year return period.

5.2 PRELIMINARY DESIGN

The preliminary design drawings are presented on drawing numbers (refer to **Annexure A**):

- **1572-GEN-001** - BBF Layout and Sections
- **1572-GEN-010** - Typical Details 01
- **1572-GEN-011** - Typical Details 02
- **1572-RDS-001** - Roads and Stormwater Layout
- **1572-RDS-CS-001** - Road Cross Sections Road 1
- **1572-RDS-CS-002** - Road Cross Sections Road 2,3,4
- **1572-RDS-CS-003** - Road Cross Sections Road 5
- **1572-RDS-CS-004** - Road Cross Sections Road 6
- **1572-RDS-CS-005** - Road Cross Sections Road 7
- **1572-RDS-LS-001** - Road Longitudinal Sections
- **1572-STW-LS-001** - Stormwater Longitudinal Sections

The PCSWMM model layout utilised to carry out the design and the associated hydraulic results are presented on **Drawing Numbers 1572-STW-001** and **002** (refer to **Annexure B**) respectively. The design elements are described in further detail below:

- The roads shall be constructed with Mountable Kerbs (MK) to provide conveyance capacity and act as cut-offs for the downstream WWTW infrastructure. 465m of road shall be served by a minor stormwater drainage system consisting of 185m of 450mm diameter and 280m of 600mm diameter stormwater pipes and associated catchpits, to allow the road cross-section to convey up to and including the 100-year return period, with the exception of one reach where approximately 200l/s will discharge downstream as overland flow for the 100-year return period. This is not considered problematic; the existing roads network currently has no conveyance capacity and no significant issues have been reported on site. These pipelines are however recommended as operationally, the occurrence of significant storm events (e.g. the 50-year and 100-year return periods) are rare. The erosion potential and scour which is highlighted in the geotechnical report is considered a risk, and utilising the road network as conveyances will provide protection downstream. An assumed maximum kerb height of 75mm has been assessed; this shall have no impact on access vehicles from a safety perspective.
- The BBF's platforming, bulk earthworks and / or roof guttering shall be designed to:
 - Drain a 2.7 hectare contributing catchment to the north-western corner of the BBF. A 600mm diameter Class 100D pipeline with an approximate length of 160m and which shall convey the 10-year return period of 0.44 m³/s shall discharge into the 600mm diameter stormwater line conveying runoff to the maturation ponds. Flows greater than the 10-year return period shall be conveyed overland in a westerly direction.
 - Drain a 0.68 hectare contributing catchment south via a 450mm diameter stormwater pipeline, which shall discharge into a new reactor (Module B). The 0.68 hectare catchment area, with an estimated 10-year peak runoff of

0.11 m³/s, shall contain the sludge stockpiles, and runoff may be contaminated; hence routing of the runoff to the reactor for treatment.

No additional stormwater infrastructure is proposed to serve the ultimate design configuration. Runoff from buildings and WWTW infrastructure shall discharge as overland flow.

5.3 HYDRAULIC RESULTS

The hydraulic assessment results for both the existing and ultimate scenarios are presented below. The following has been assessed:

- The hydraulic performance of each of the four maturation ponds (inflow, water depth, water level, outflow) for the 100-year return period have been tabulated in **Table 9**; with Pond 1 being the most upstream pond and Pond 4 the most downstream pond. The location of the four maturation ponds are presented on **Drawing Number 1752-STW-001** (refer to **Annexure B**).
- The impact of the WWTW on the Gwaing River.

Table 9: Maturation Pond Assessment (100-Year Return Period)

Parameter	Maturation Pond 1		Maturation Pond 2		Maturation Pond 3		Maturation Pond 4	
	EHES	FHFS	EHES	FHFS	EHES	FHFS	EHES	FHFS
Maximum Inflow (m³/s)	2.852	3.842	2.297	3.211	0.916	1.148	1.566	0.676
Maximum Storage Volume (m³)	9 922	10 533	6 012	8 323	13 208	13 182	16 675	16 660
Maximum Storage Depth (m)	2.36	2.42	1.75	2.12	1.99	1.99	2.15	2.15
Weir Level* (m above Invert Level) (m)	2.147		2.500		2.400		2.100	
Freeboard (Weir Level – Water Level) (m)	-0.213	-0.273	0.75	0.38	0.410	0.410	-0.050	-0.050
Maximum Embankment Level (mamsl)	186.397		186.159		185.021		184.864	
Water Level (mamsl)	185.66	185.72	183.91	184.27	183.71	183.71	183.7	183.7
Pond Freeboard (Maximum Embankment Level – Water Level)#	0.737	0.677	2.249	1.889	1.311	1.311	1.164	1.164
Maximum Outflow (m³/s)	1.913	2.778	0.92	1.157	0.364	0.723	0.139	0.116

*The weir level refers to the embankment between the maturation ponds, which is lower than the main embankments. This will route runoff between ponds if runoff discharges over it, but will not necessarily overtop the main pond embankments.

The freeboard indicated is the freeboard within the ponds. Should freeboard not be available, then the pond(s) will overtop the main embankments and shall either convey runoff into the open space between the maturation ponds to the east, or directly into the Gwaing River or its tributary to the west and south.

It is observed in **Table 9** that the results for the existing and ultimate scenarios generally have similar hydraulic performance within the maturation ponds. This is due to:

- The approximately 5% increase in impervious area is observed to have a limited impact in terms of storm peak flows and associated volumes (refer to **Section 3.2.4** for the comparison between the EHES and FHFS hydrology). The greatest impact noted in terms of hydraulics are the inflows into Maturation Pond 1 with an increase in estimated peak inflow increasing from 2.85 m³/s to 3.84 m³/s. The hydraulic performance (storage volumes, pipe flows and weir flows) of Ponds 2, 3 and 4 reduce the outflows downstream to close to the existing scenario discharge as the ponds are controlled via 500mm diameter pipes which have limited conveyance capacity.
- In addition, the process control design as per ReflektWater estimates a maximum peak flow of 115 l/s / 0.115 m³/s inflow into maturation ponds, which is slightly less than the 0.123 m³/s estimated for the existing scenario.
- The existing chlorine contact tank which treats the discharge from the maturation ponds and the 1050mm diameter and 900mm diameter pipelines serving it has a limited conveyance capacity and acts as the hydraulic control.

In terms of the ultimate design scenario on the runoff discharging from the WWTW into the Gwaing River, the following was found:

- The peak flow increased from 12.672 m³/s for the Existing Scenario to 13.242 m³/s for the ultimate design scenario for the 100-year return period. This equates to an increase of 0.572 m³/s.
- From an overall catchment perspective, the contributing catchment area of the Gwaing River adjacent to the WWTW is estimated to exceed 35 km². Therefore, the peak discharge emanating from the WWTW shall pass downstream before the arrival of the peak within the Gwaing River. The impact of the WWTW on the Gwaing River shall therefore be negligible.

6 CONCLUSIONS AND RECOMMENDATIONS

6.1 CONCLUSIONS

The proposed stormwater drainage system for the Gwaing WWTW for the ultimate design scenario shall consist of:

- The roads shall be constructed with Mountable Kerbs (MK) to provide conveyance capacity and act as cut-offs for the downstream WWTW infrastructure. 465m of road shall be served by a minor stormwater drainage system consisting of 185m of 450mm diameter and 280m of 600mm diameter stormwater pipes and associated catchpits, to allow the road cross-section to generally convey up to and including the 100-year return period.
- The BBF's platforming, bulk earthworks and / or roof guttering shall be designed to:
 - Drain a 2.7 hectare contributing catchment to the north-western corner of the BBF. A 600mm diameter Class 100D pipeline with an approximate length of 160m and which shall convey the 10-year return period of 0.44 m³/s shall discharge into the 600mm diameter stormwater line conveying runoff to the maturation ponds. Flows greater than the 10-year return period shall be conveyed overland in a westerly direction.
 - Drain a 0.68 hectare contributing catchment south via a 450mm diameter stormwater pipeline, which shall discharge into a new reactor. The 0.68 hectare catchment area, with an estimated 10-year peak runoff of 0.11 m³/s, shall contain the sludge stockpiles, and runoff may be contaminated; hence routing of the runoff to the reactor for treatment.
- All other runoff shall consist of overland / surface flow with no structural stormwater drainage infrastructure proposed.
- The existing maturation ponds shall not overtop the main embankments (i.e. excluding the berms acting as weirs between the four maturation ponds); therefore direct discharge into the Gwaing River and its tributary shall not occur for up to and including the 100-year return period storm event.

6.2 RECOMMENDATIONS

It is recommended that:

- The proposed stormwater drainage system be utilised during the ECSA Stage 3 (Detailed Design) stage of the project.
- Due to the erodible nature of the soils, it is recommended that suitable localised measures be considered at each building and structure (e.g. earthworks profiling to route surface runoff around the building / structure) to avoid potential scour / undercutting of foundations. This would form part of the detailed design and is not considered to be bulk stormwater infrastructure.
- Erosion protection must be constructed at all stormwater outlets to mitigate erosion.
- The open areas should be suitably vegetated and maintained to protect the natural soils from erosion.



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12 DECEMBER 2025

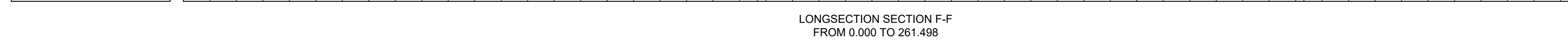
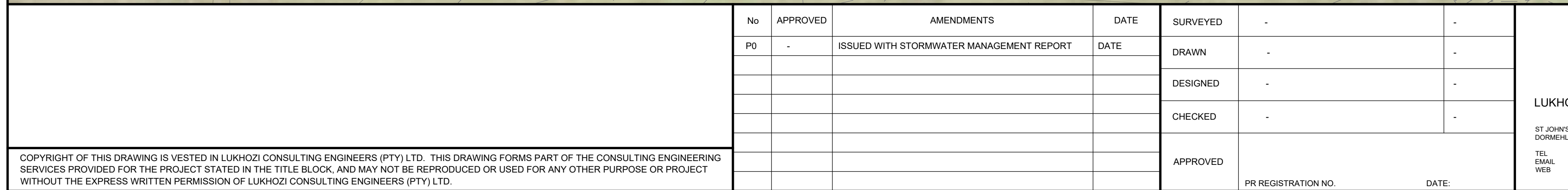
7 REFERENCES

The following key reference documents were utilised in the compilation of this report:

- Section L, Stormwater, of the “The Neighbourhood Planning and Design Guide” (The DHS Red Book), compiled by the South African Department of Human Settlements (2019).

ANNEXURE A

CONCEPT DESIGN DRAWINGS



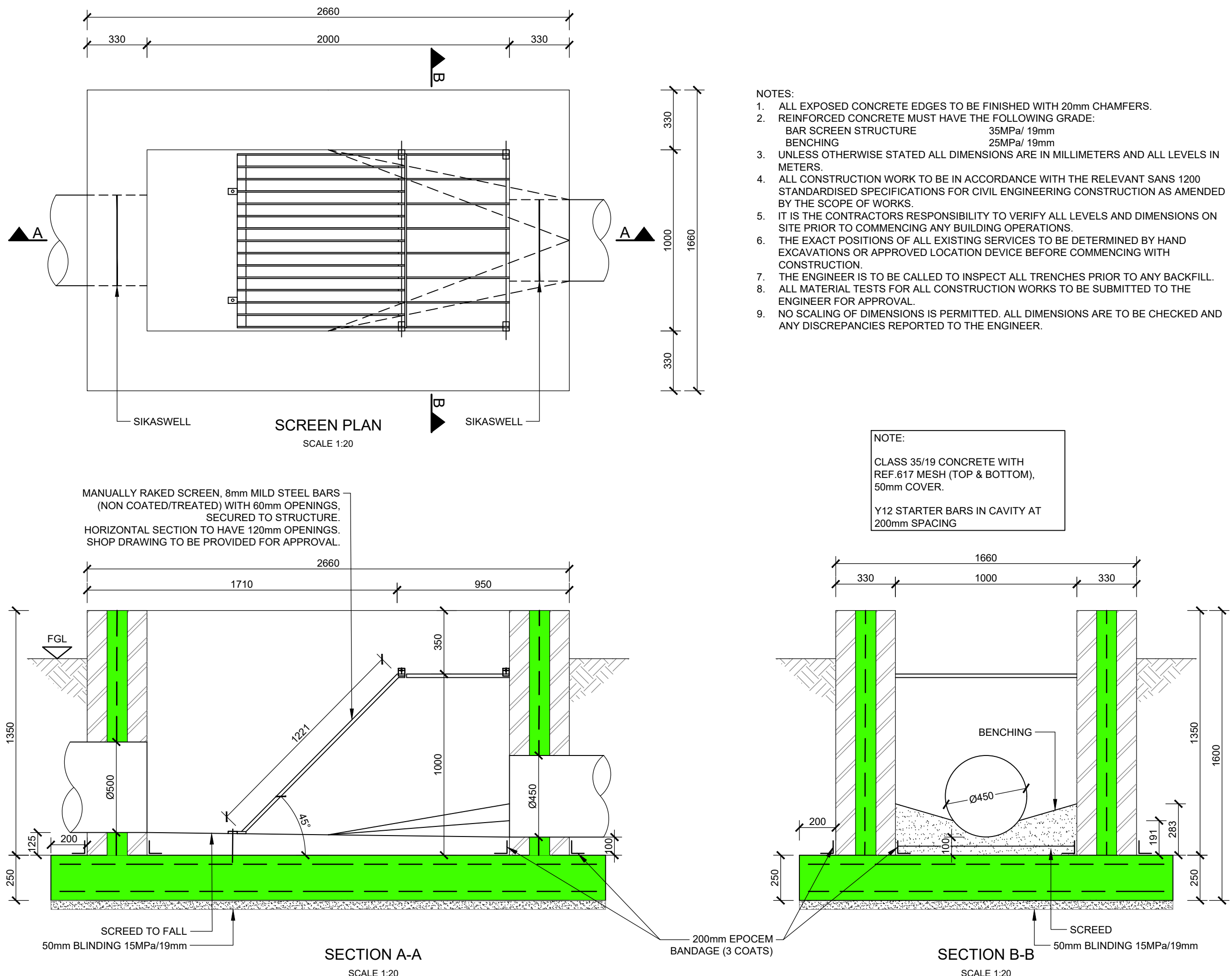
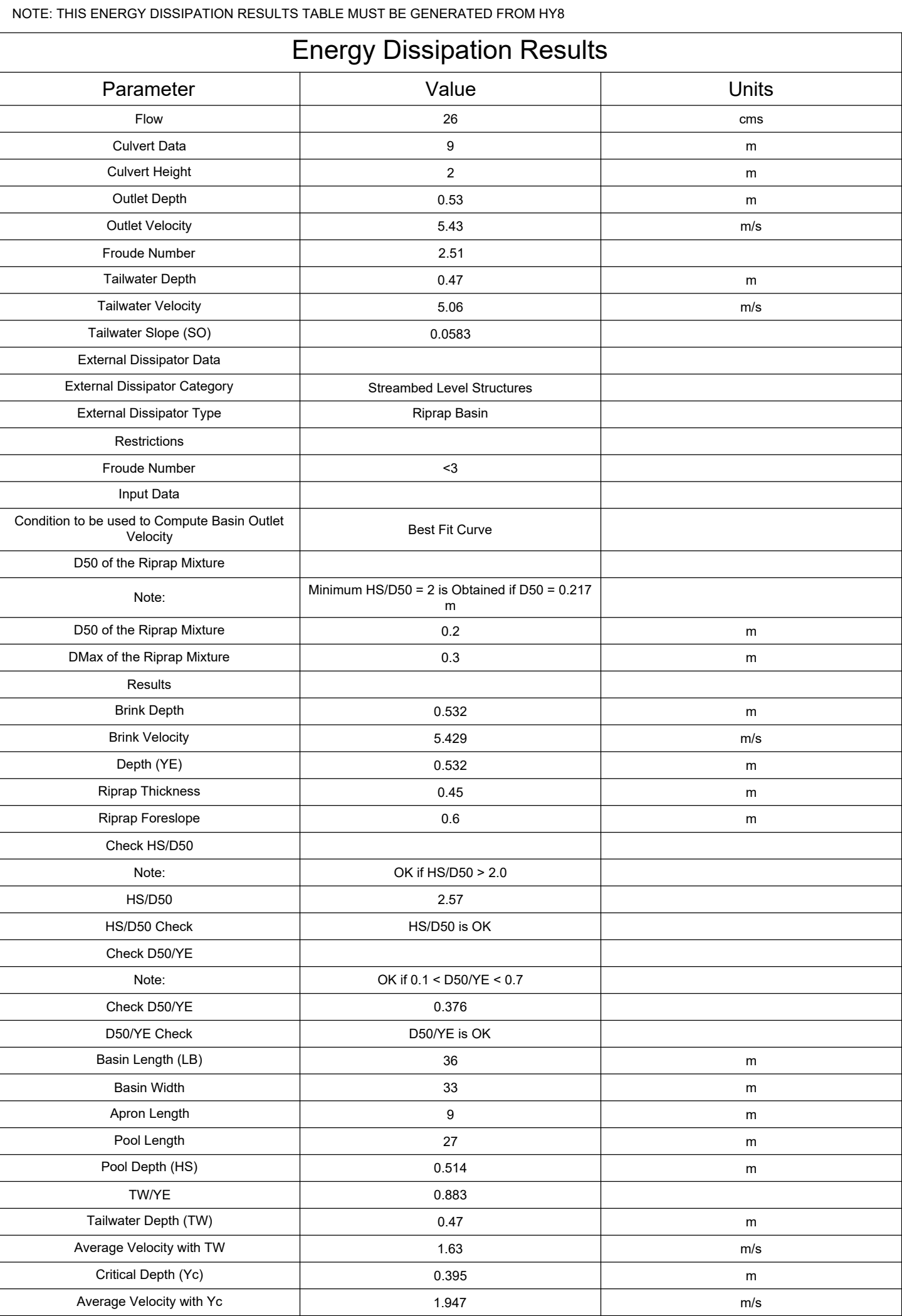
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				DESIGNED	-	-
				CHECKED	-	-
				APPROVED		
				PR REGISTRATION NO.		DATE:



DRAWING TITLE

BIO-SOLIDS BENEFICATION FACILITY (BBF)
LAYOUT AND SECTIONS

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DRAWING No. 1752-GEN-001		REVISION P0



No.	APPROVED	AMENDMENTS	DATE	SURVISED	-	-
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				DESIGNED	-	-
				CHECKED	-	-
				APPROVED		
				PR REGISTRATION NO.		DATE:

LUKHOZI



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PROJECT TITLE

GWAING WASTE WATER
TRETMENT WORKS UPGRADE

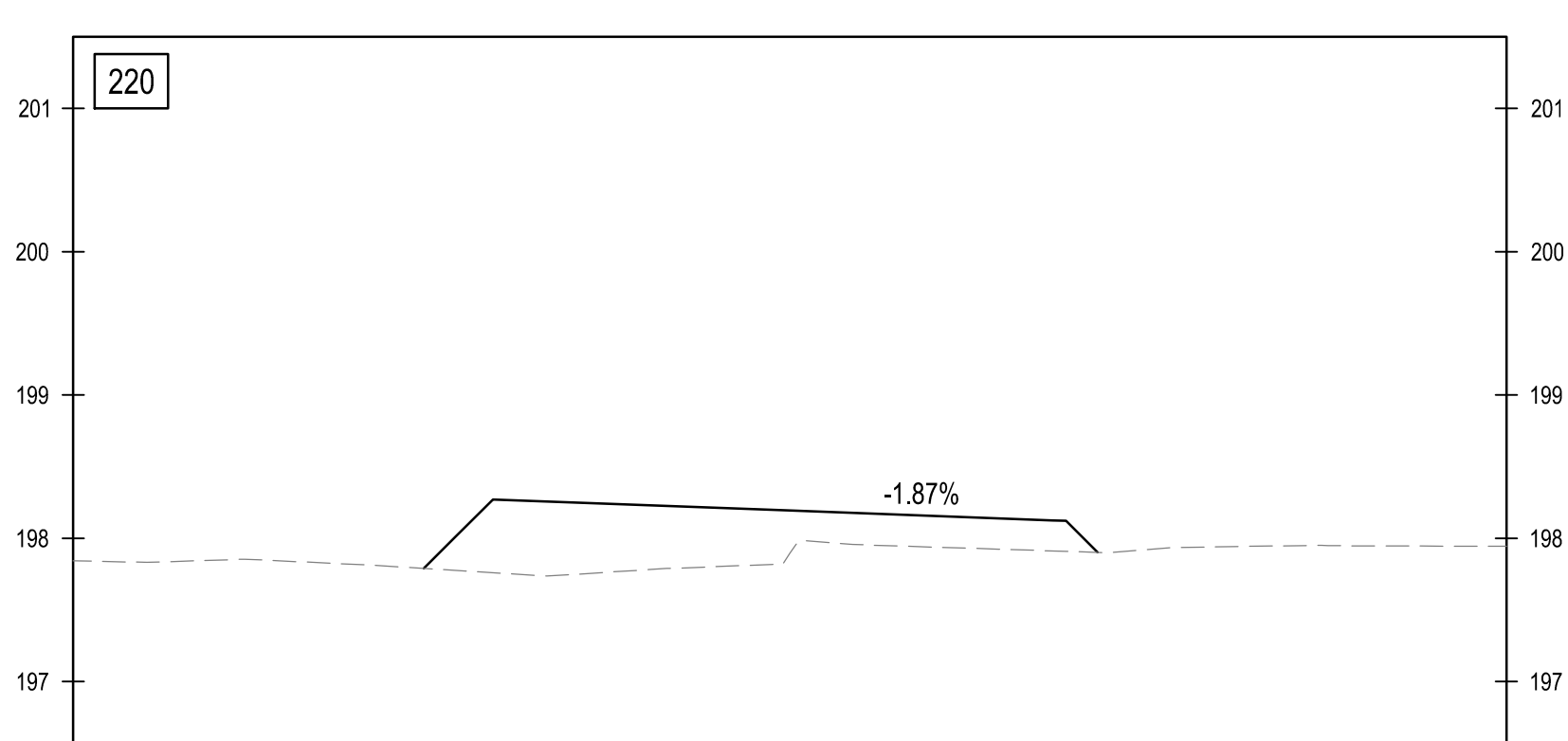
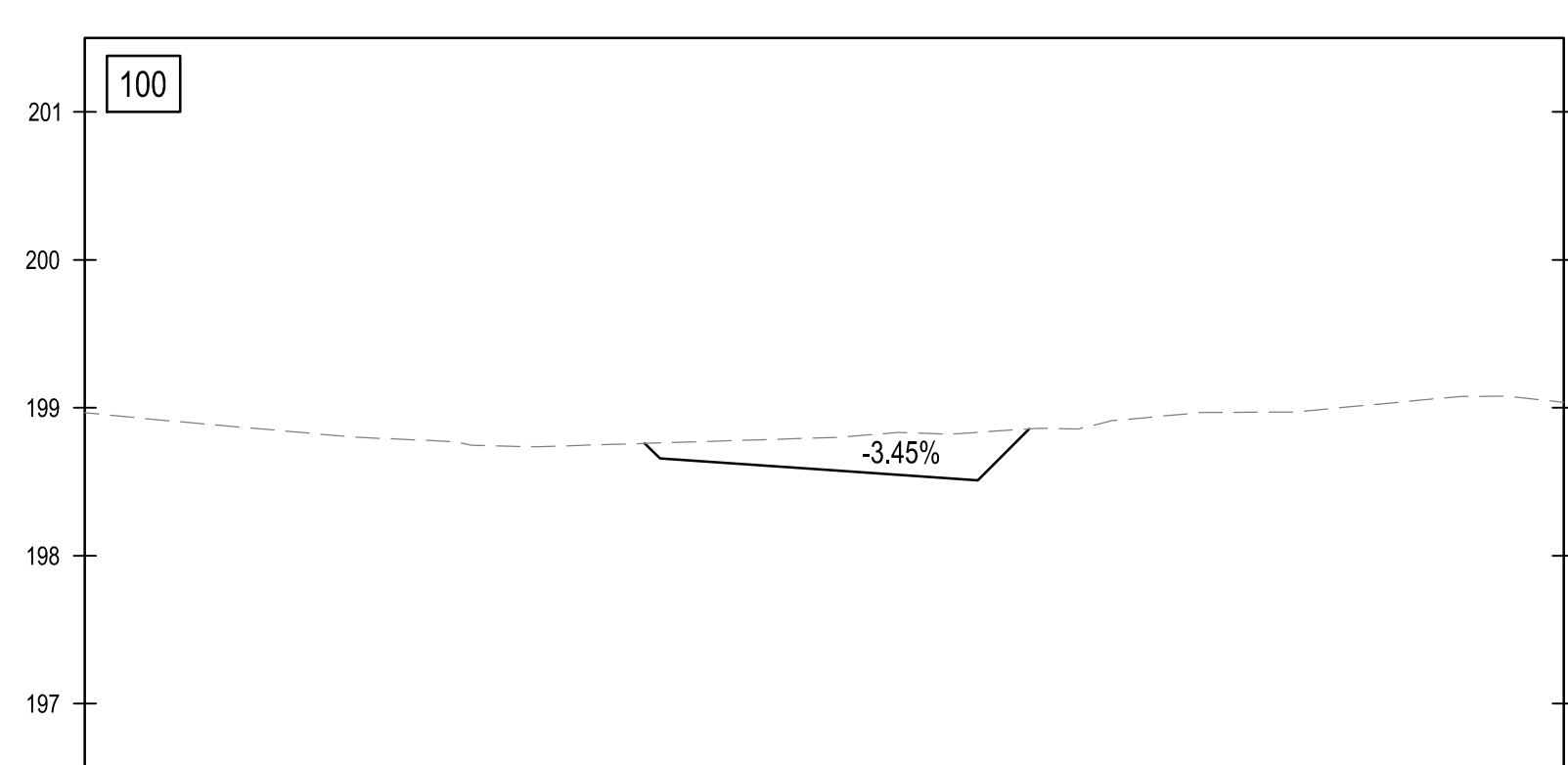
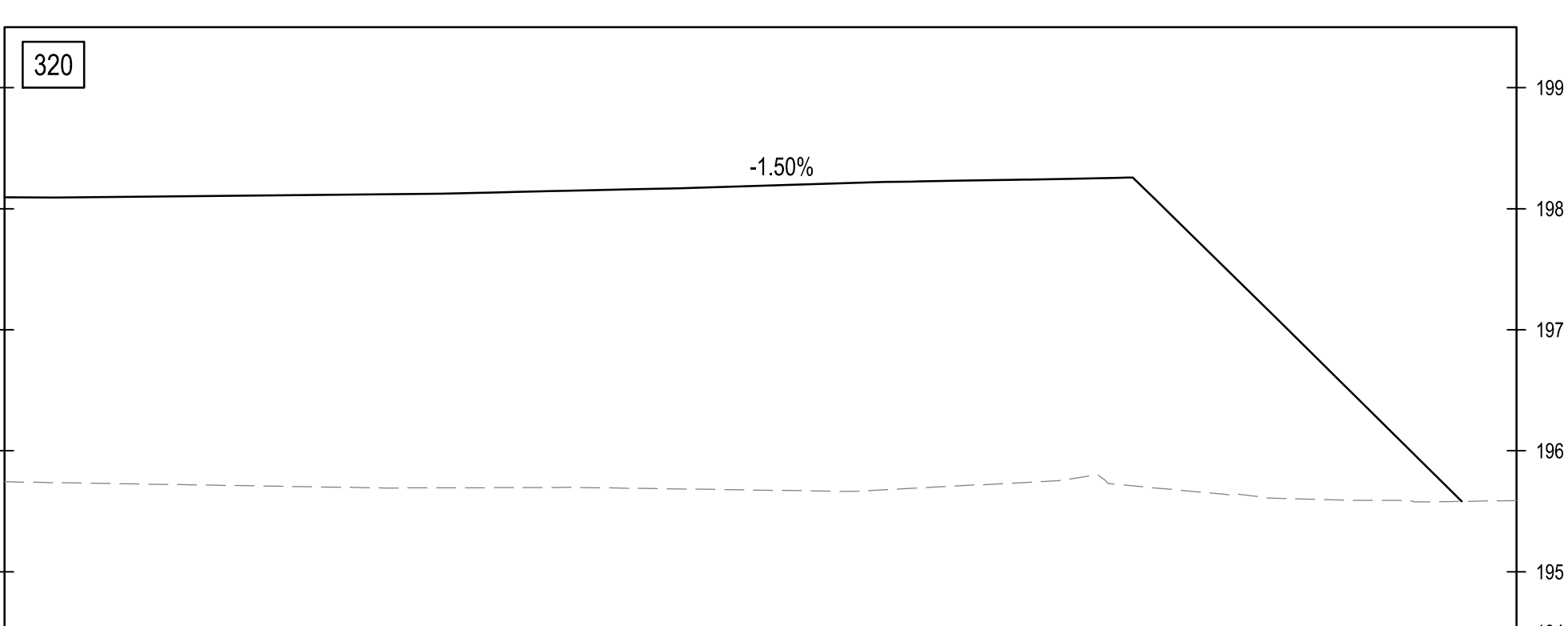
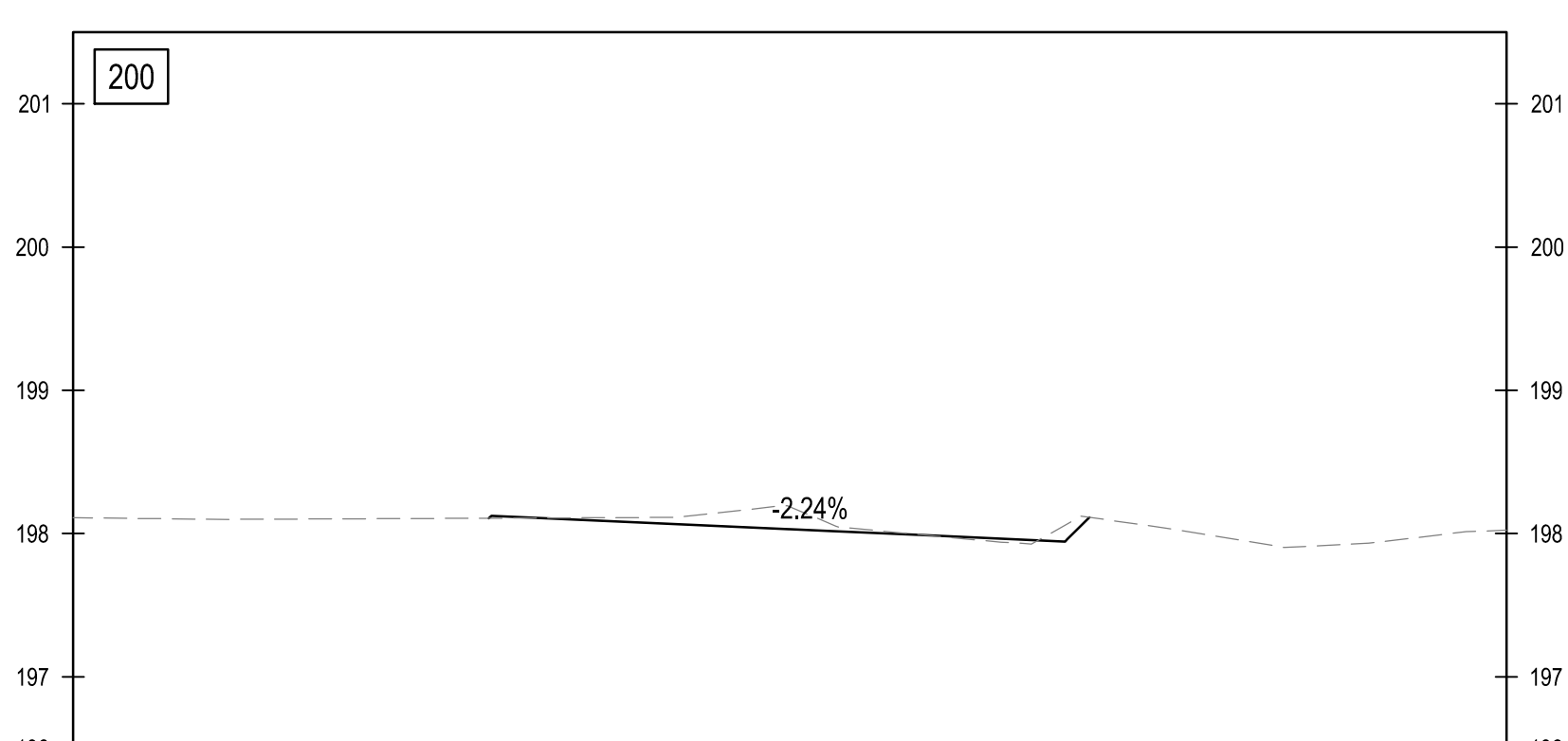
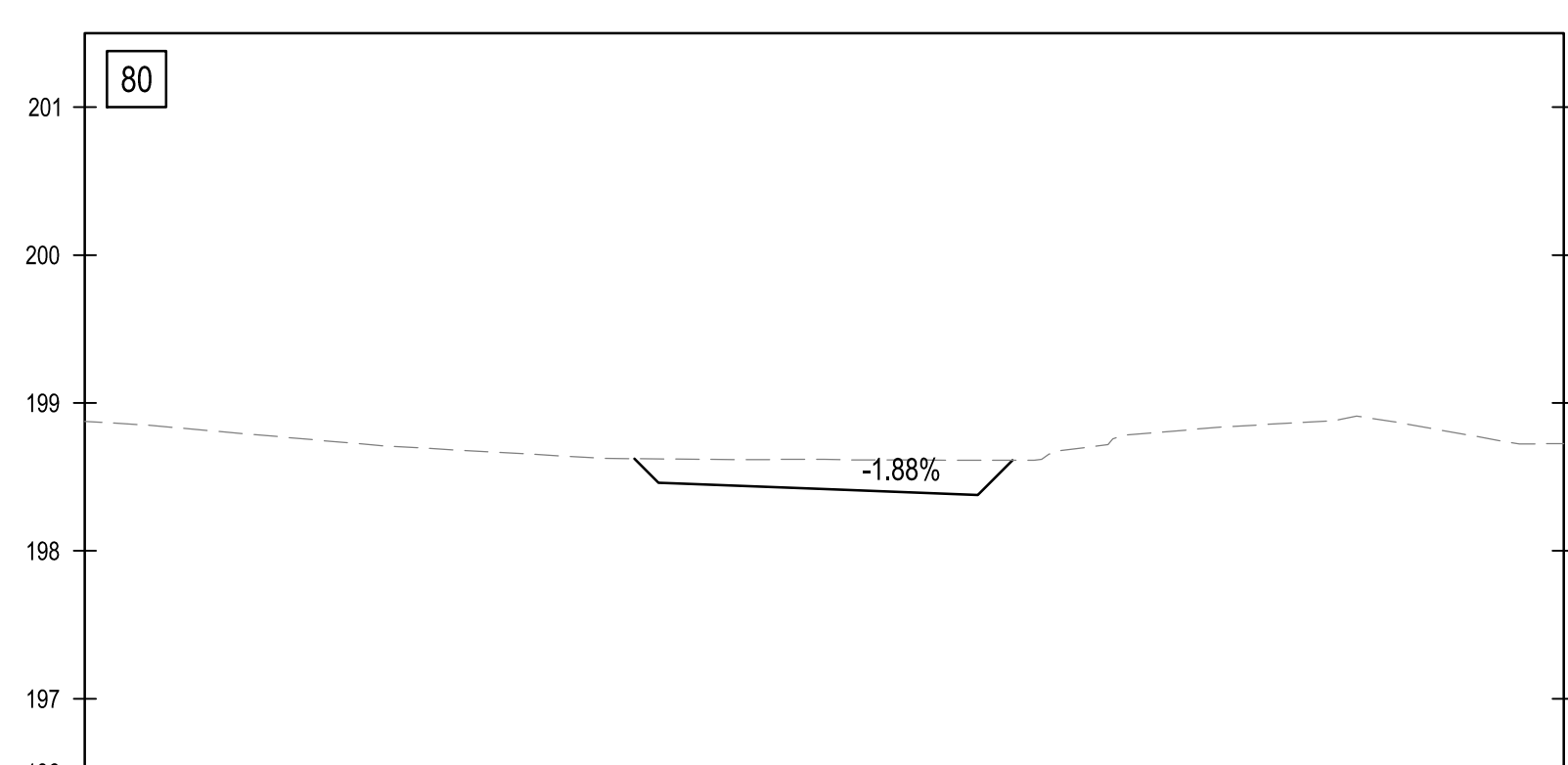
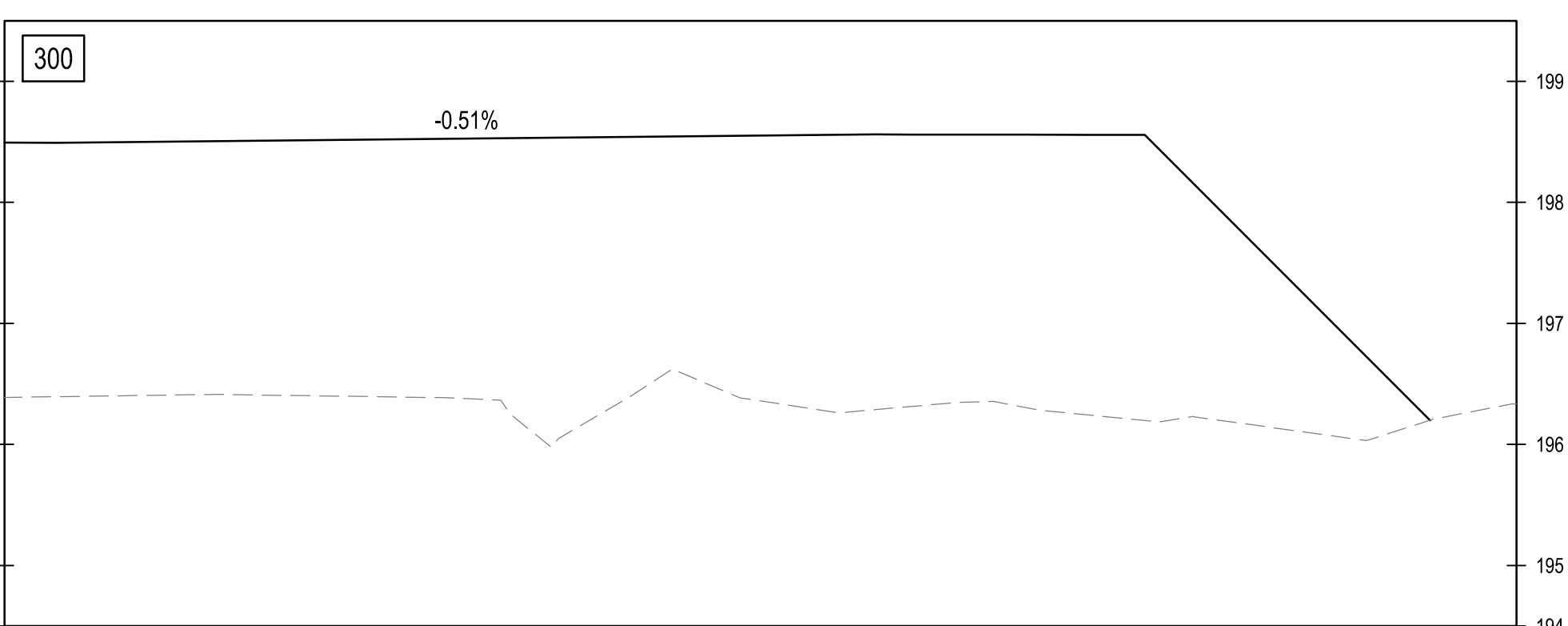
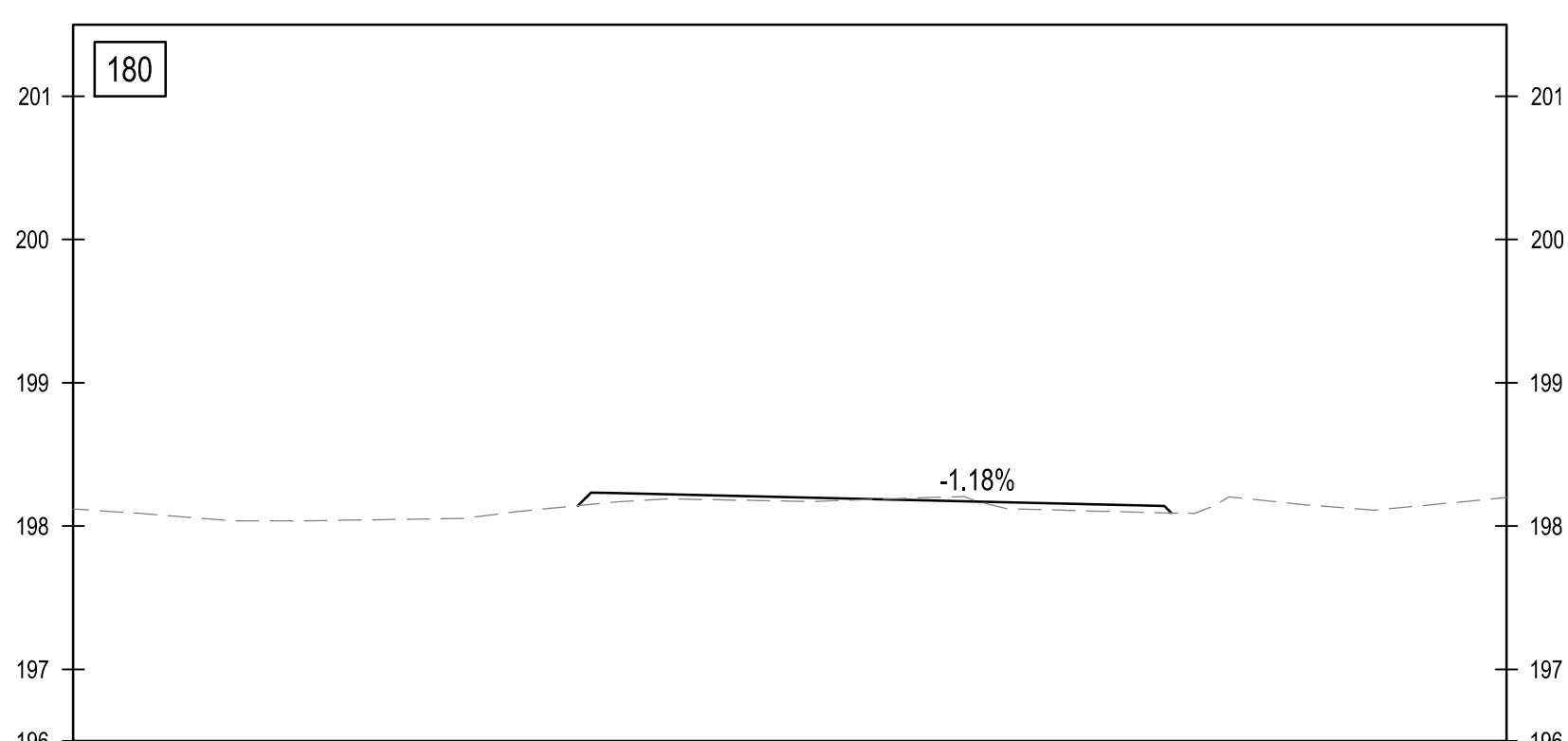
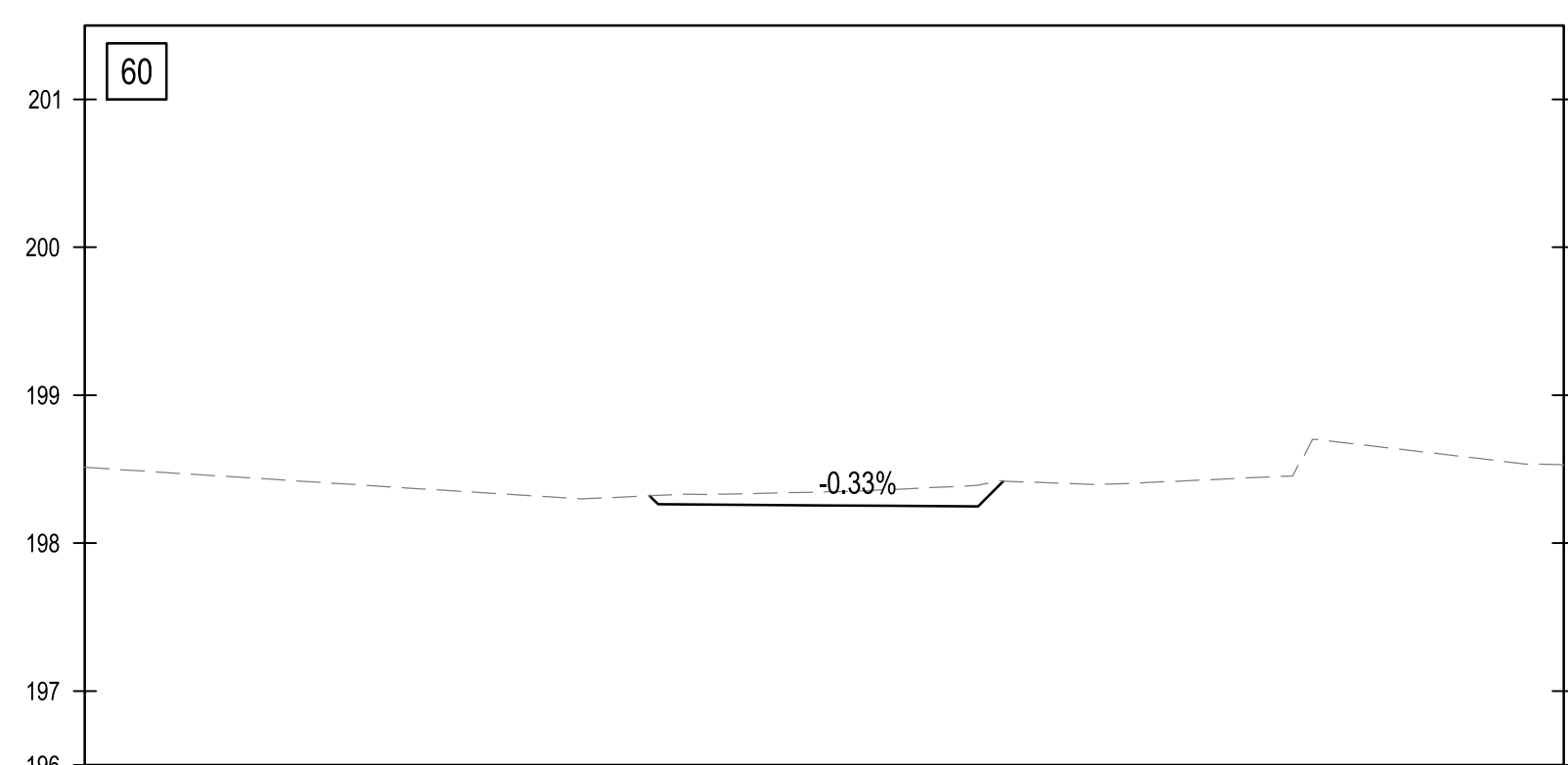
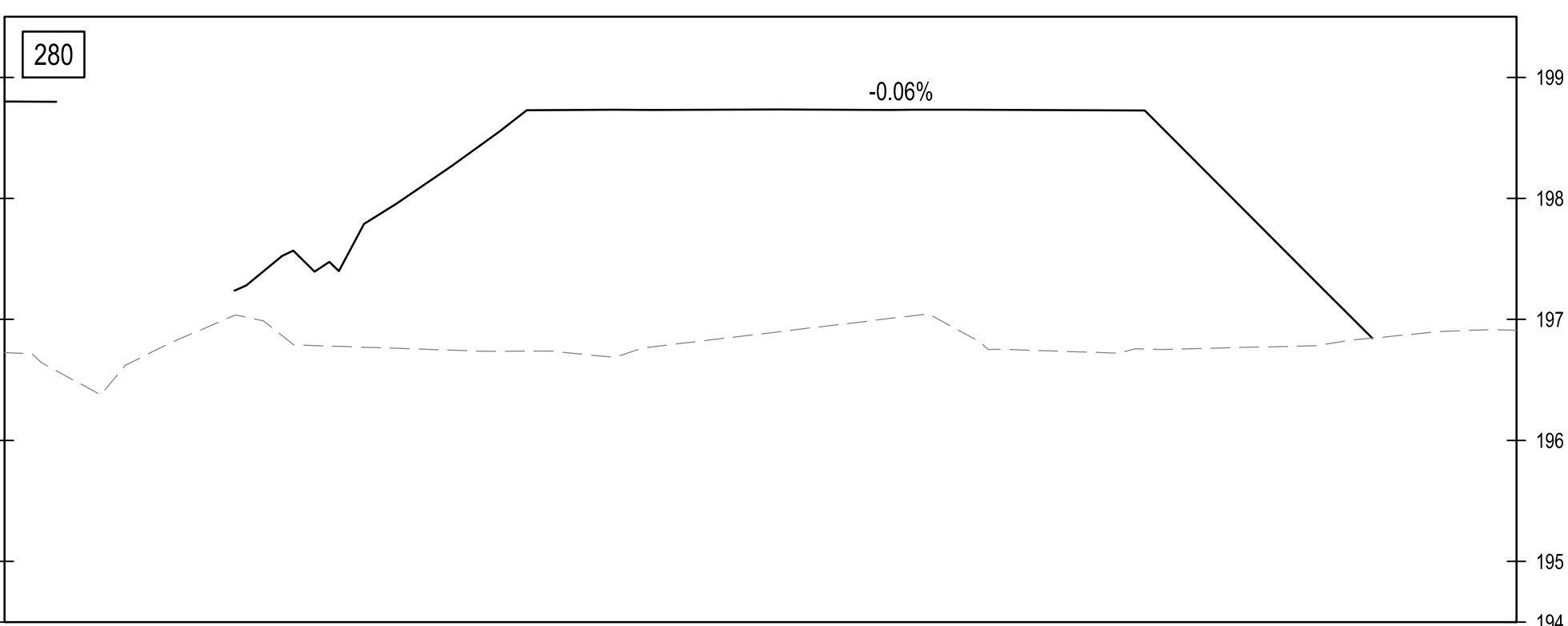
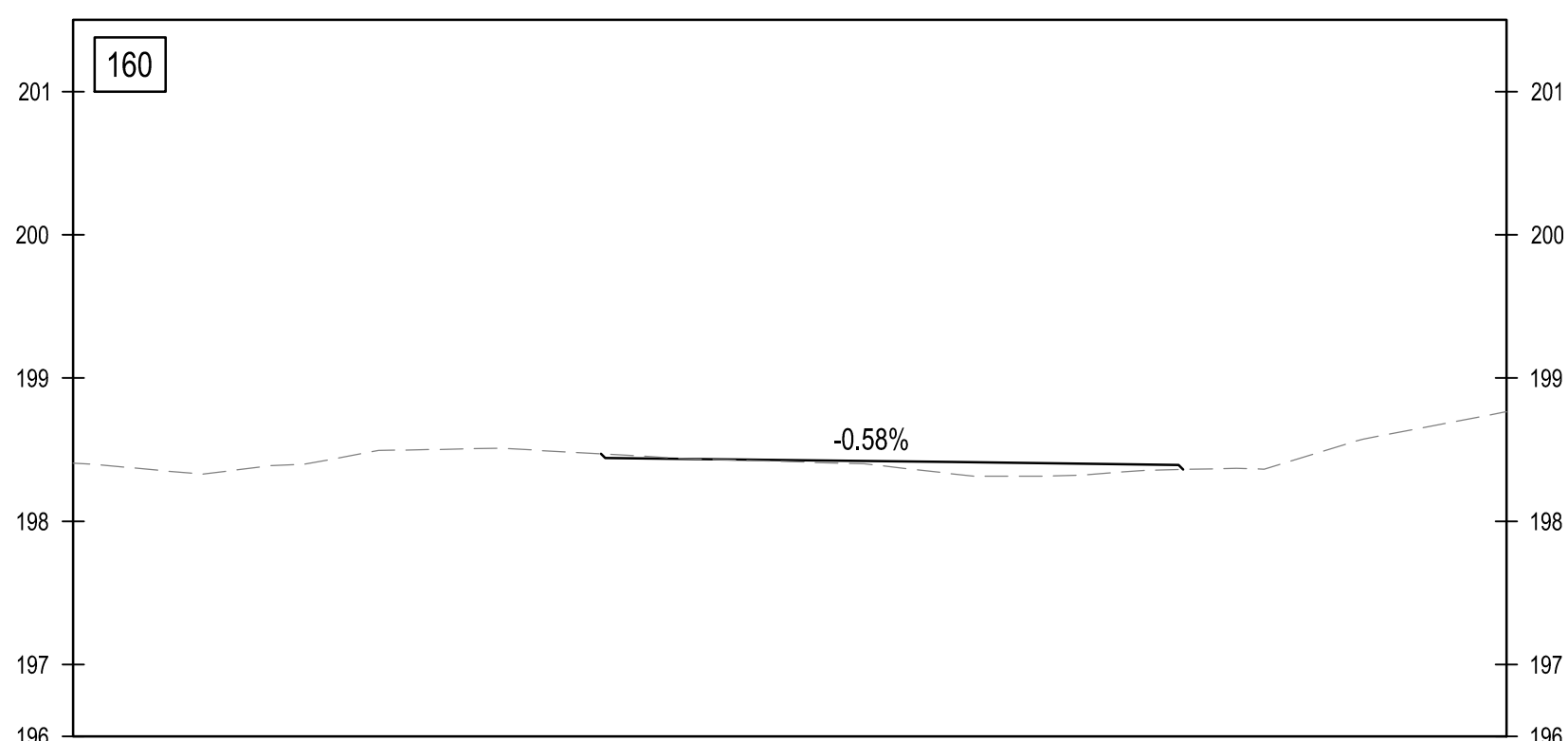
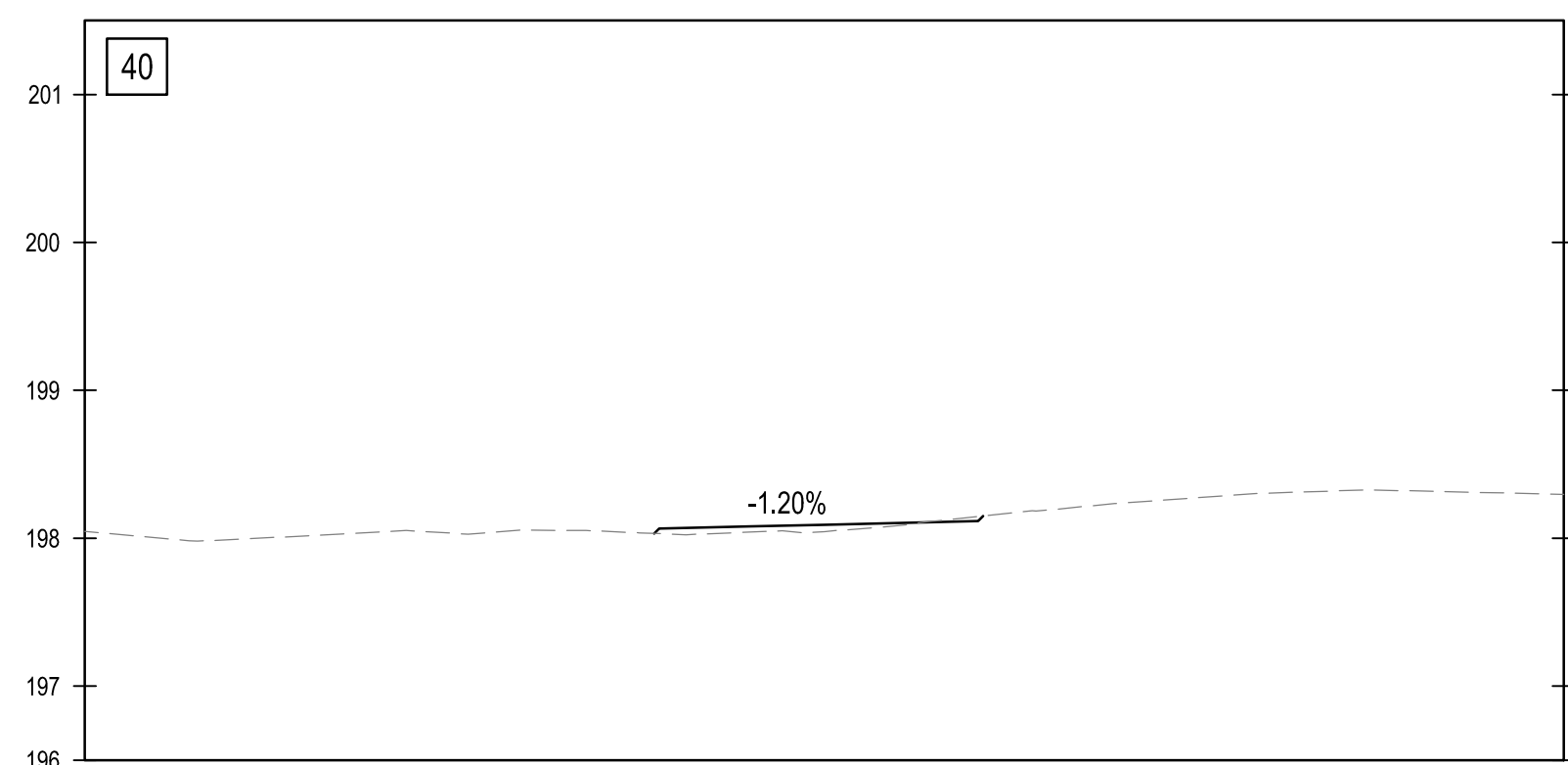
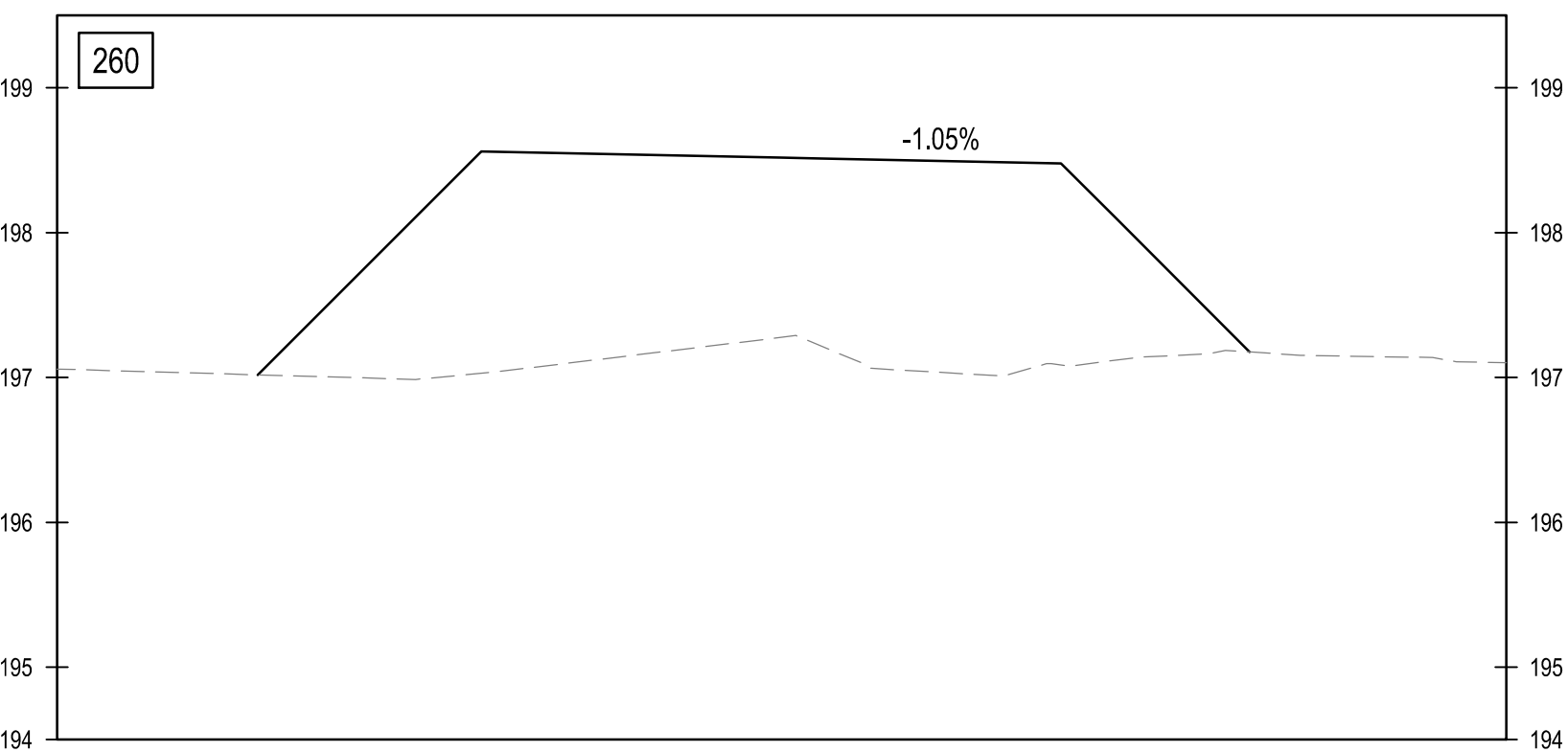
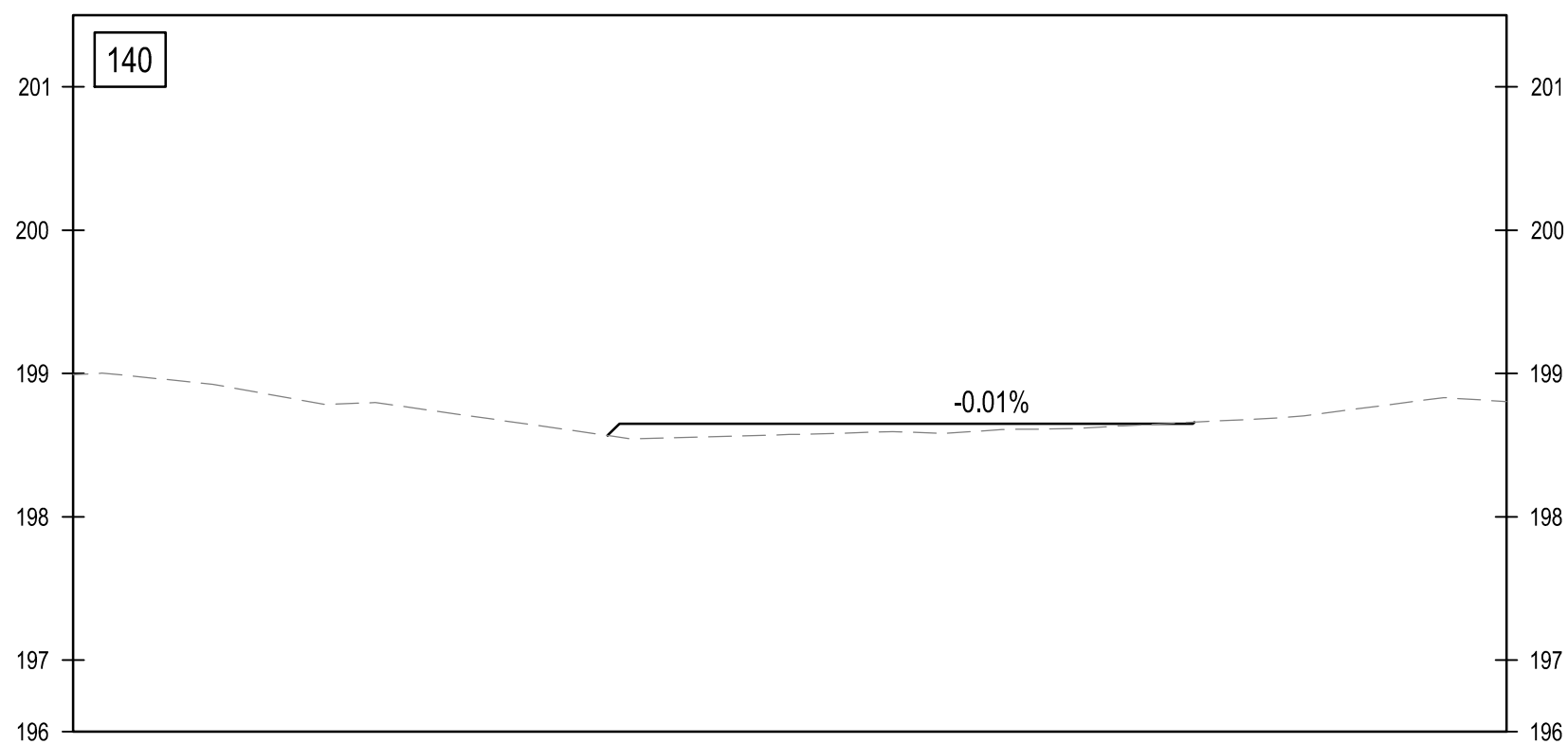
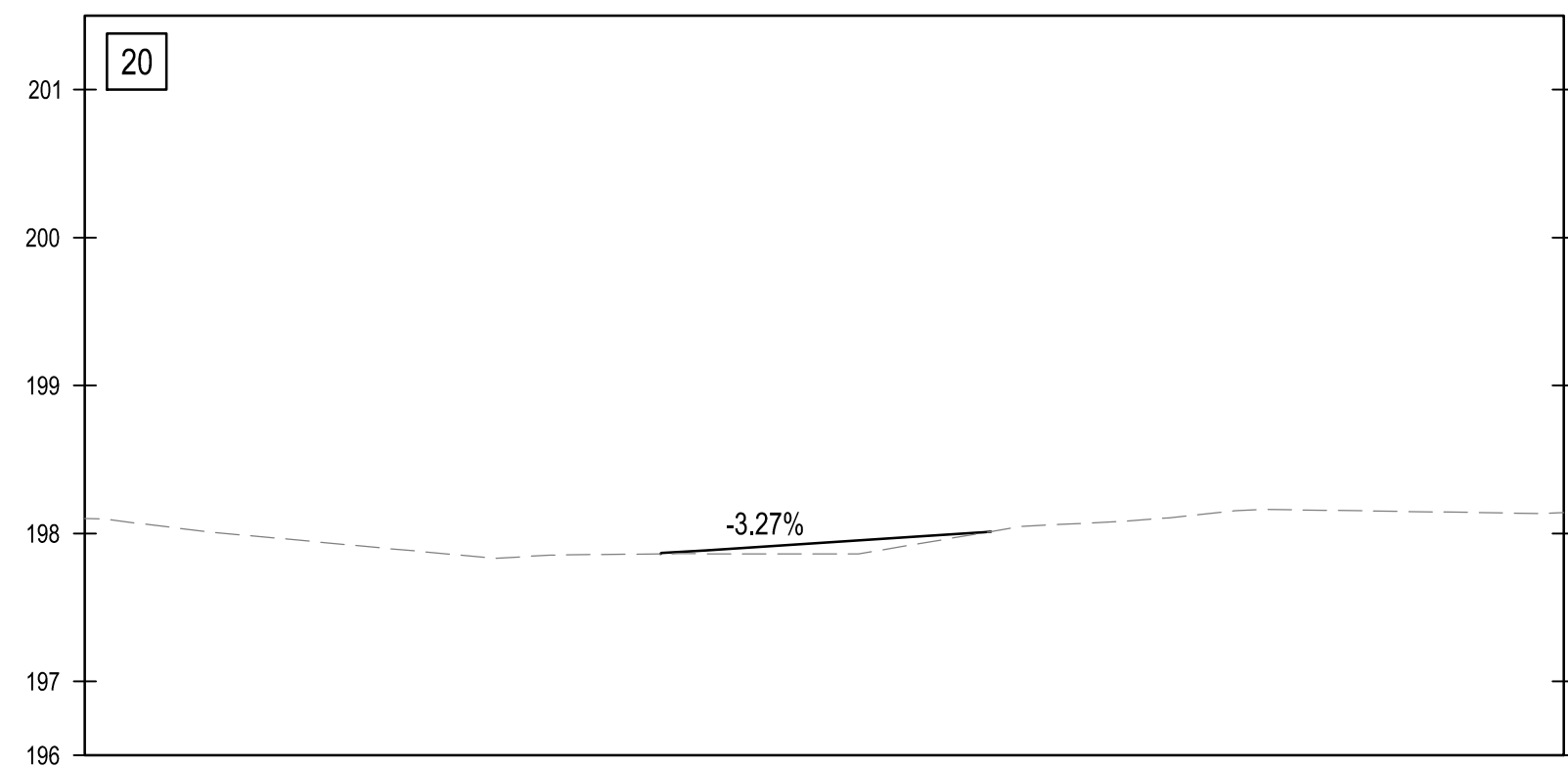
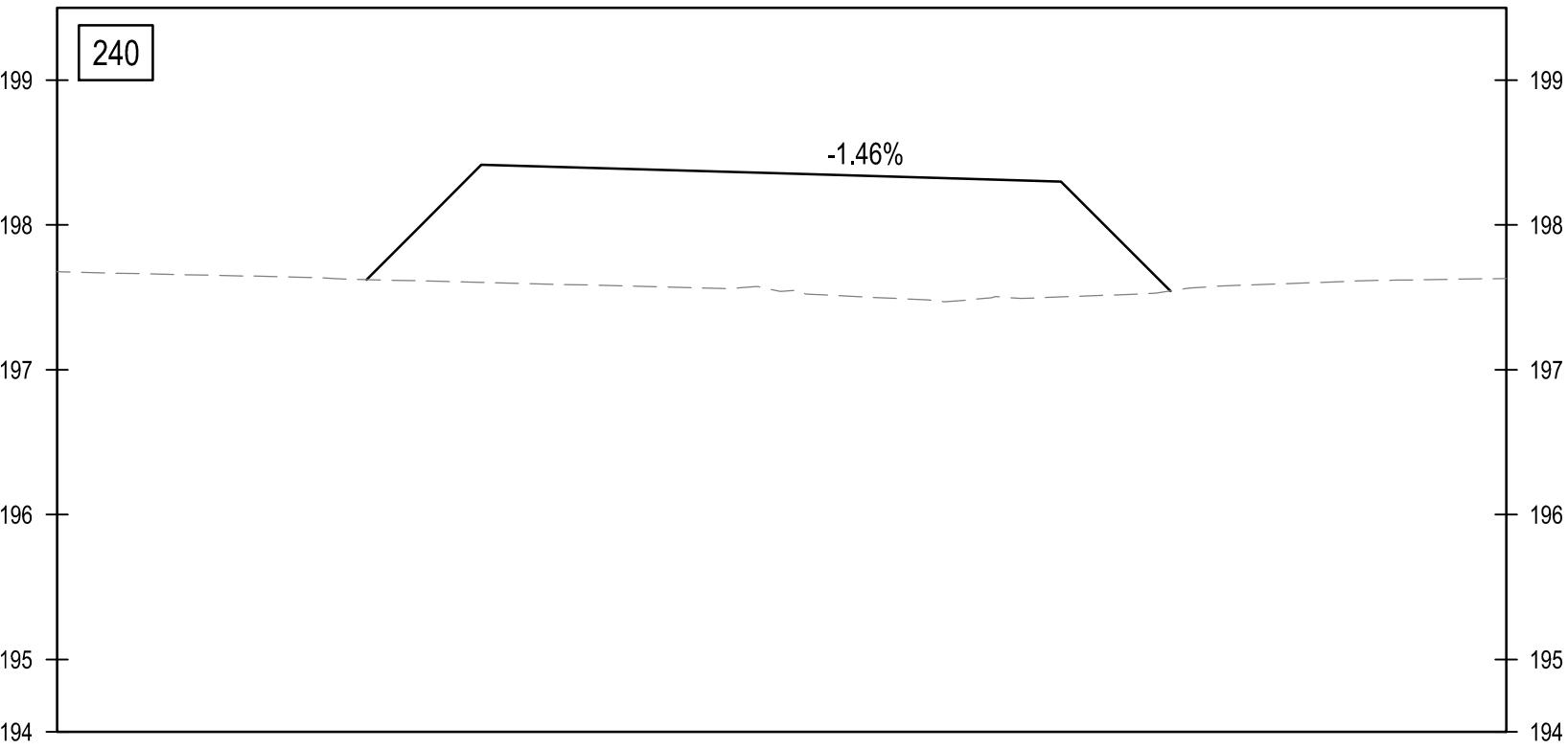
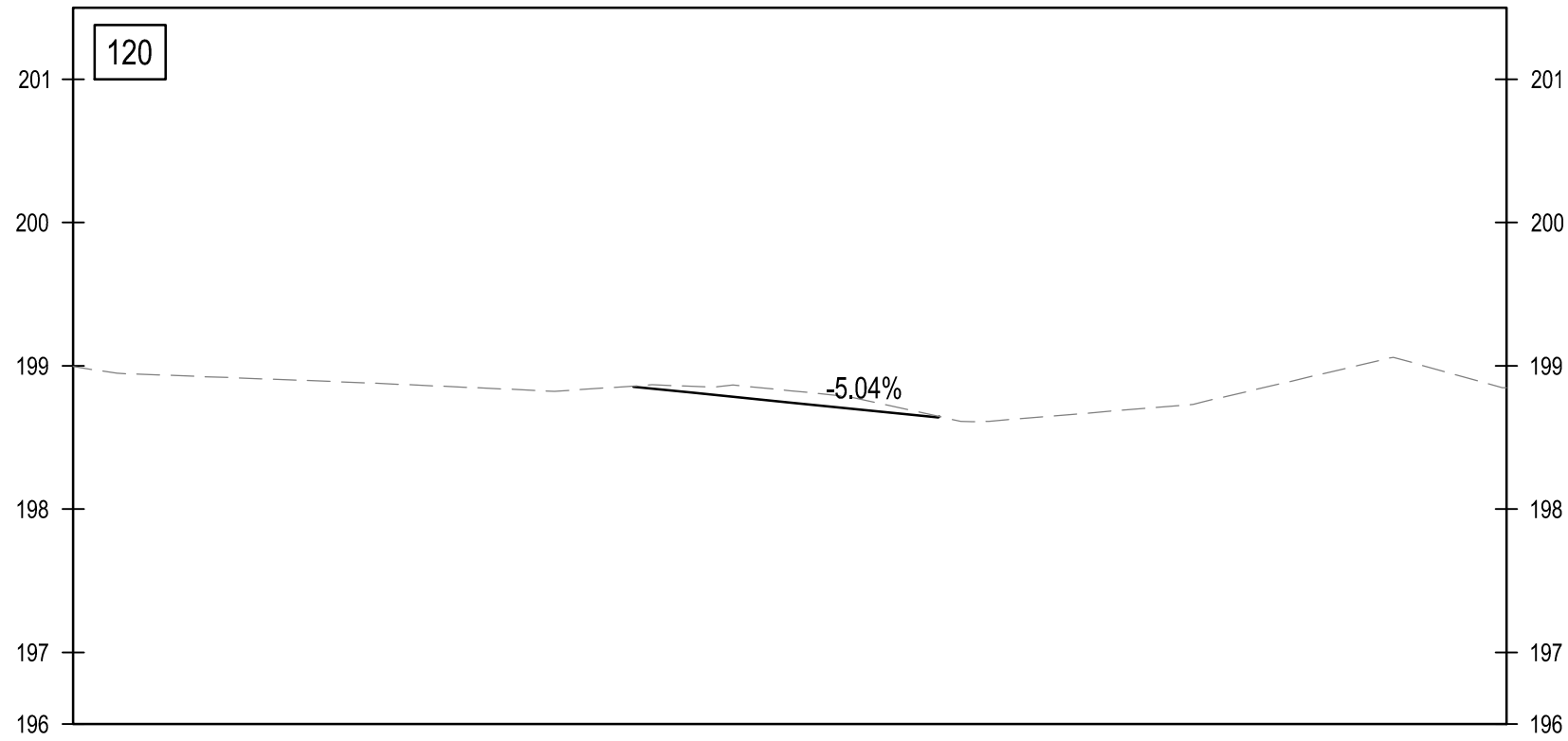
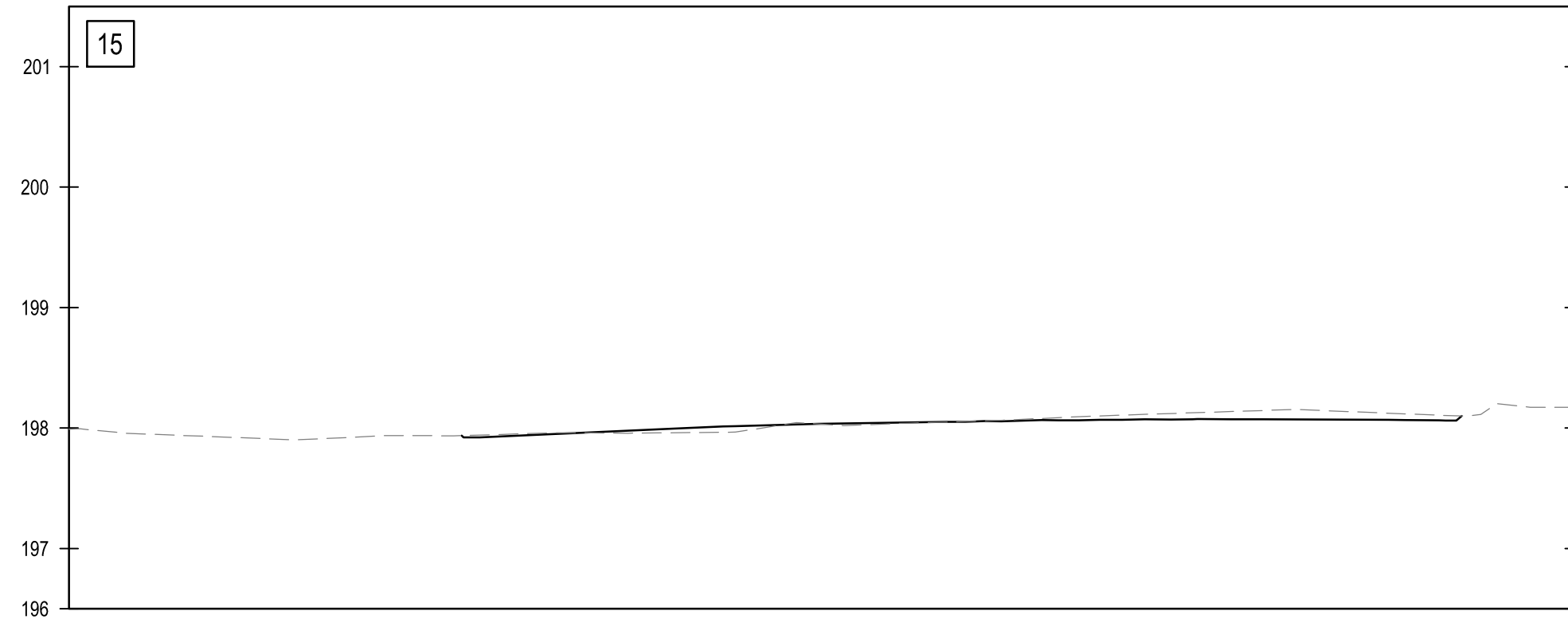
DRAWING TITLE

TYPICAL DETAILS 02

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DRAWING No.	
1752-GEN-011	



FIG. 8 MOUNTABLE KERBS & FIG. 14 CHANNEL FIG. 10 EDGING KERBS	No.	APPROVED	AMENDMENTS	DATE	SURVEYED	-	-	LUKHOZI ST JOHN'S PLACE, 3 ST JOHN'S STREET, DORSET, 4001, GEORGE TEL: 041 554 5154 FAX: 041 554 5155 WWW.LUKHOZI.CO.ZA LUKHOZI CONSULTING ENGINEERS (PTY) LTD REGISTERED ENGINEERING CONSULTANTS	CLIENT	GEORGE THE CITY FOR ALL REASONS GEORGE MUNICIPALITY	PROJECT TITLE	GWAING WASTE WATER TREATMENT WORKS UPGRADE	DRAWING TITLE	ROADS AND STORMWATER LAYOUT	SCALE	SHEET SET	SHEET SIZE																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																																												
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P/E REGISTRATION NO.		DATE:	

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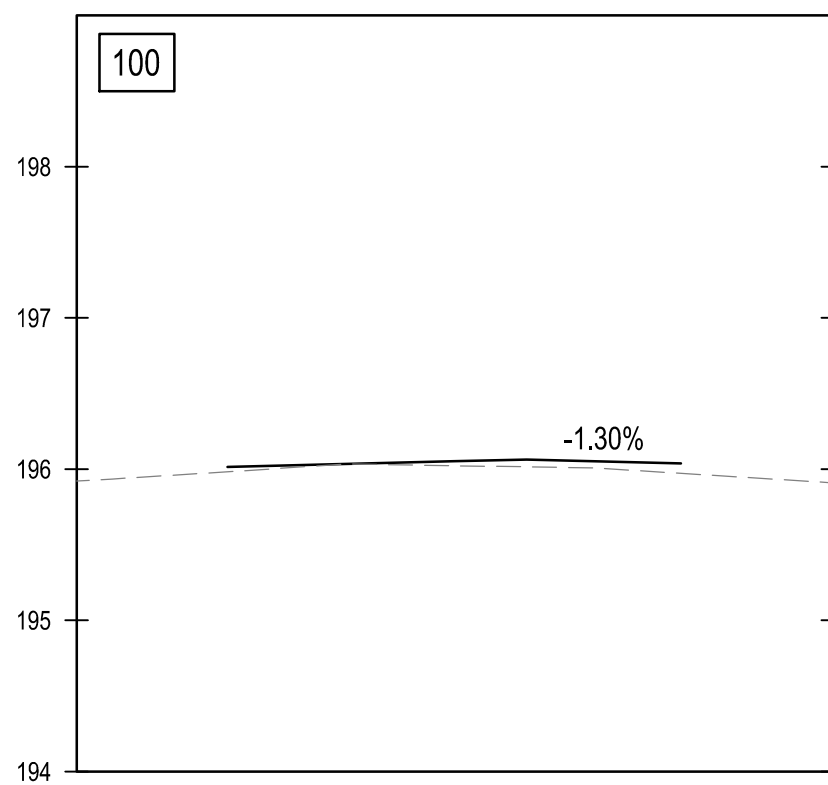
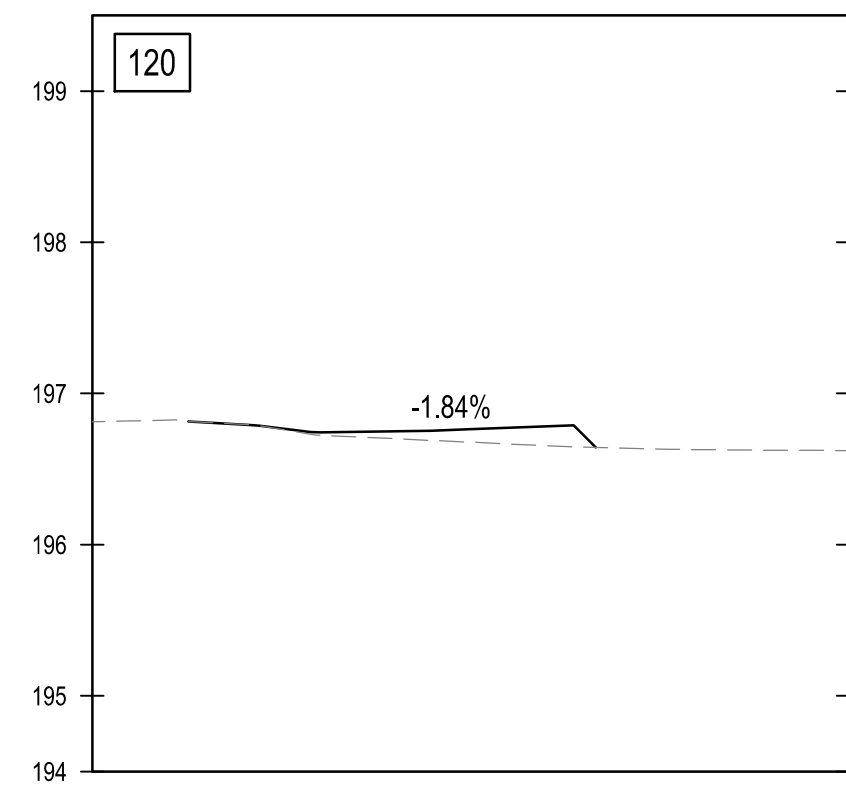
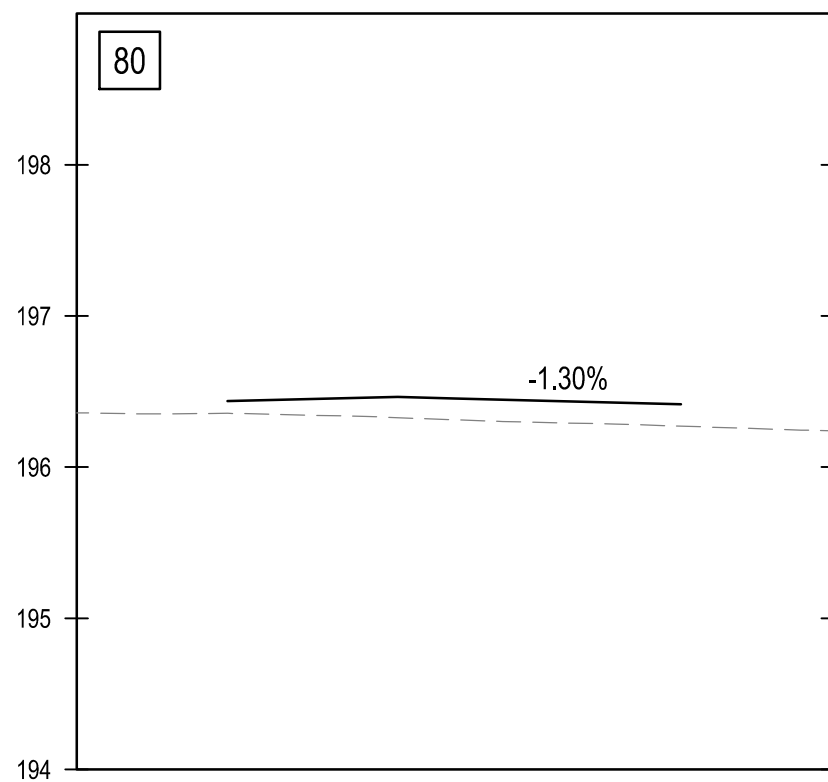
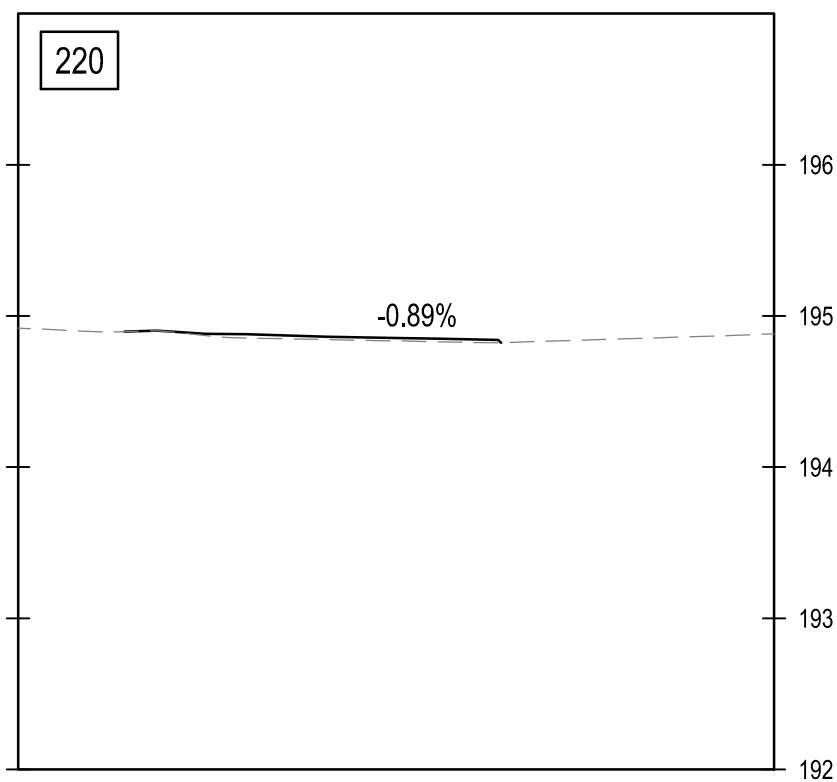
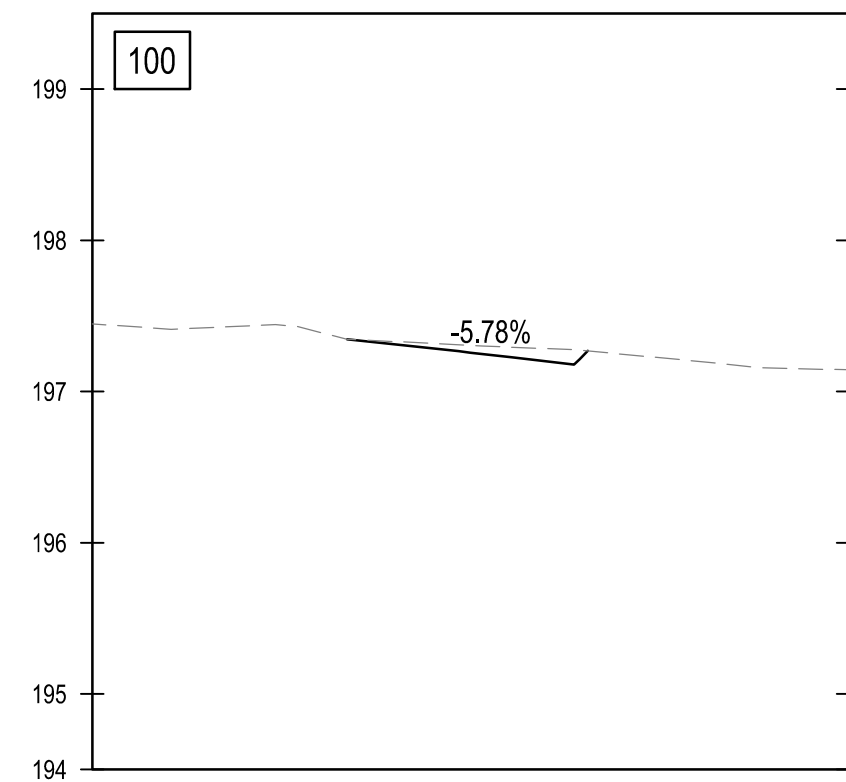
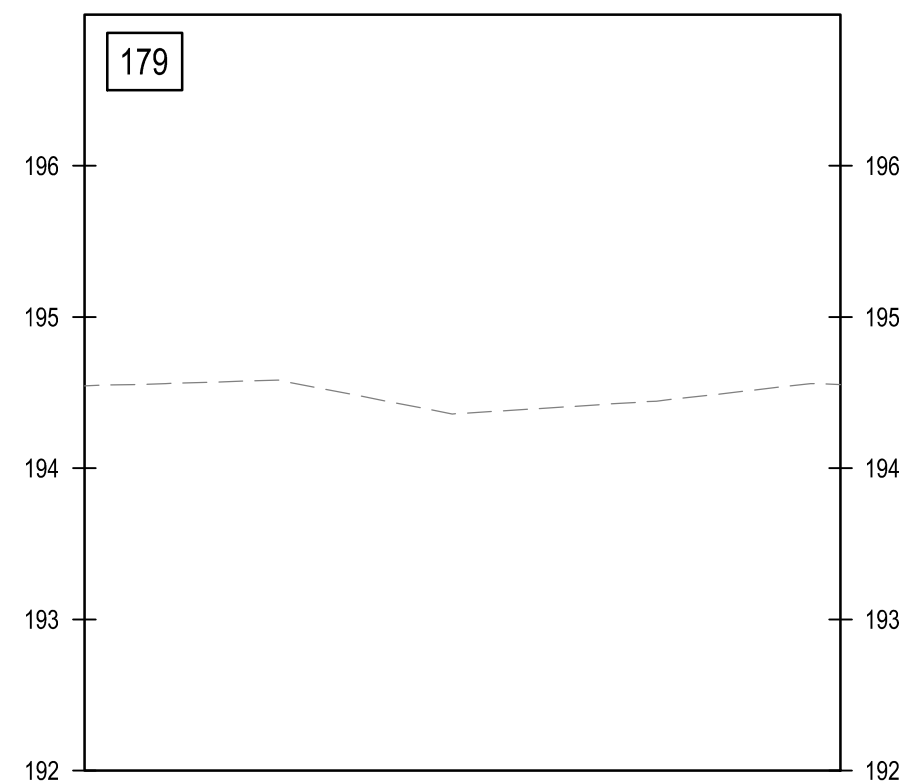
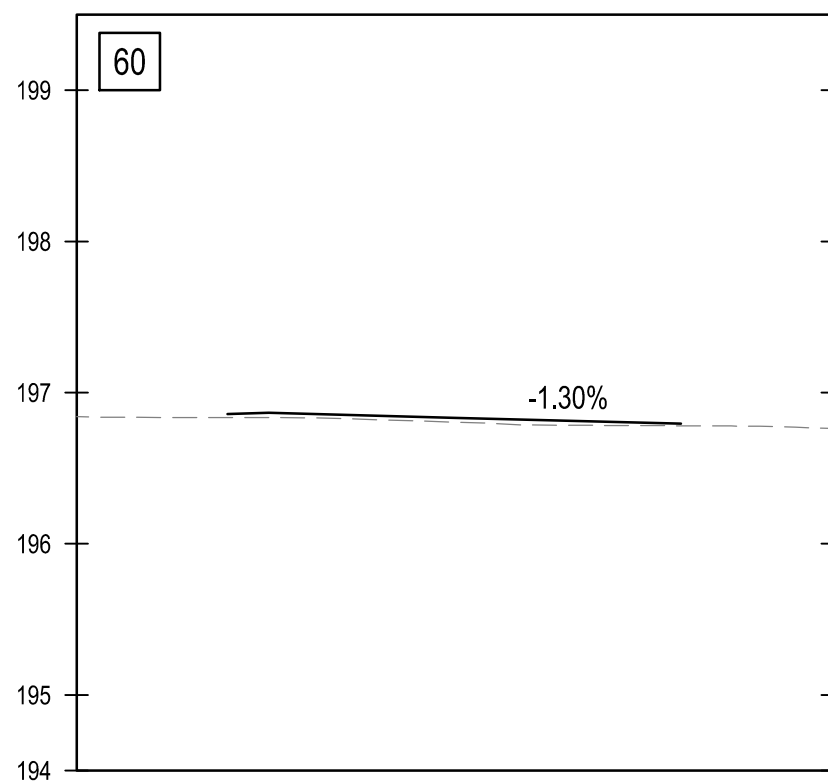
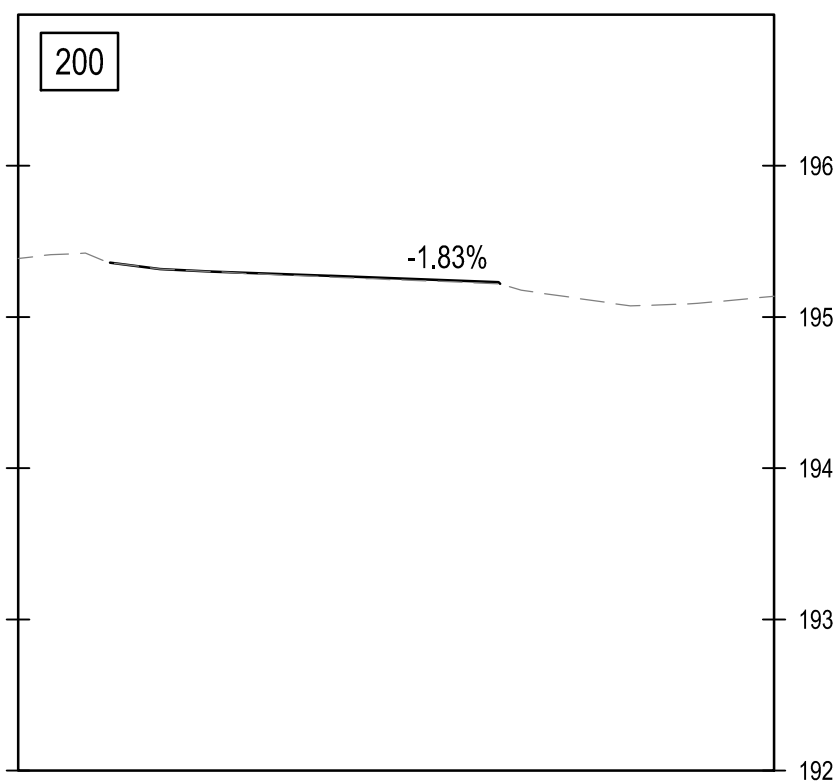
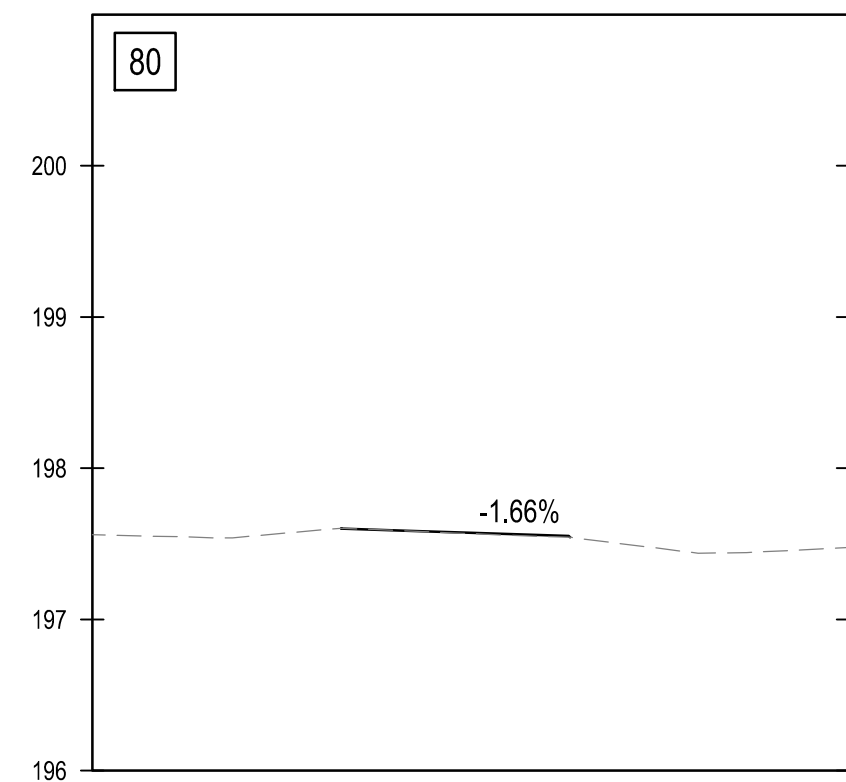
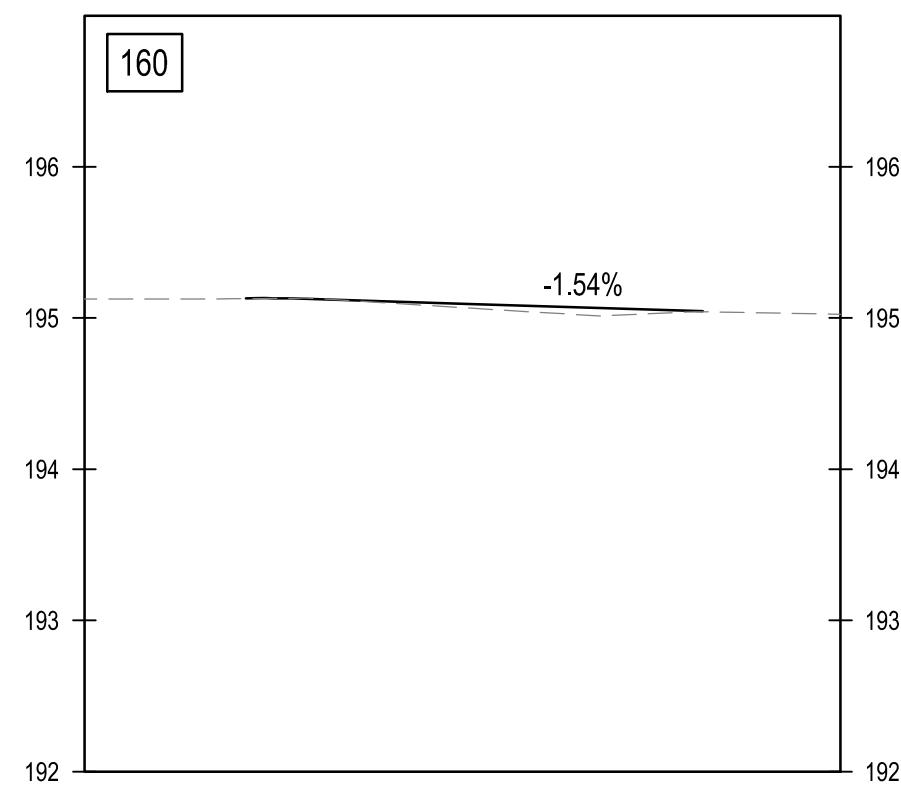
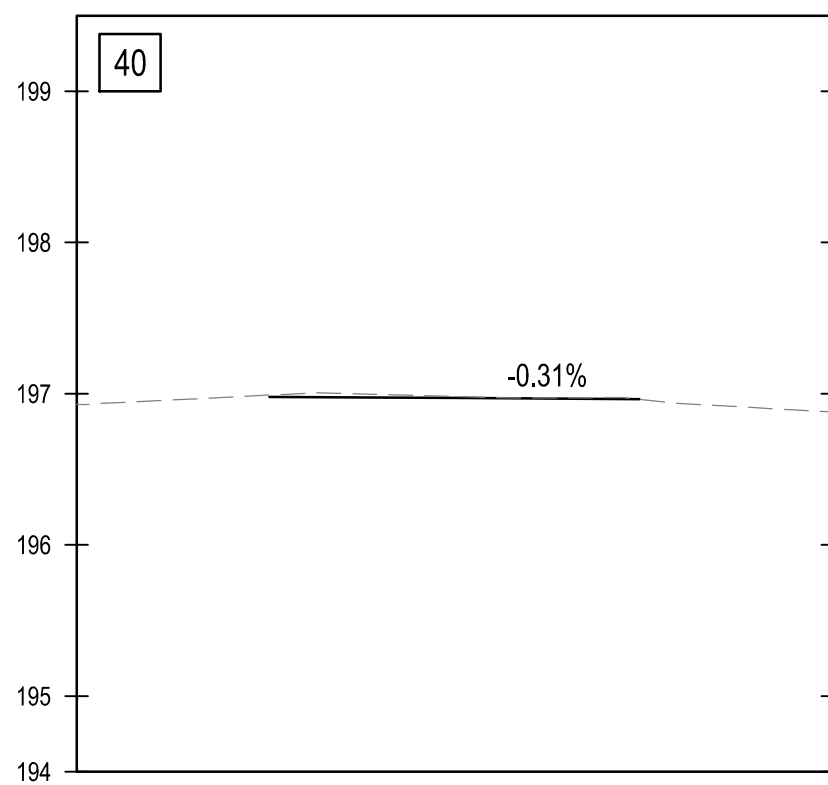
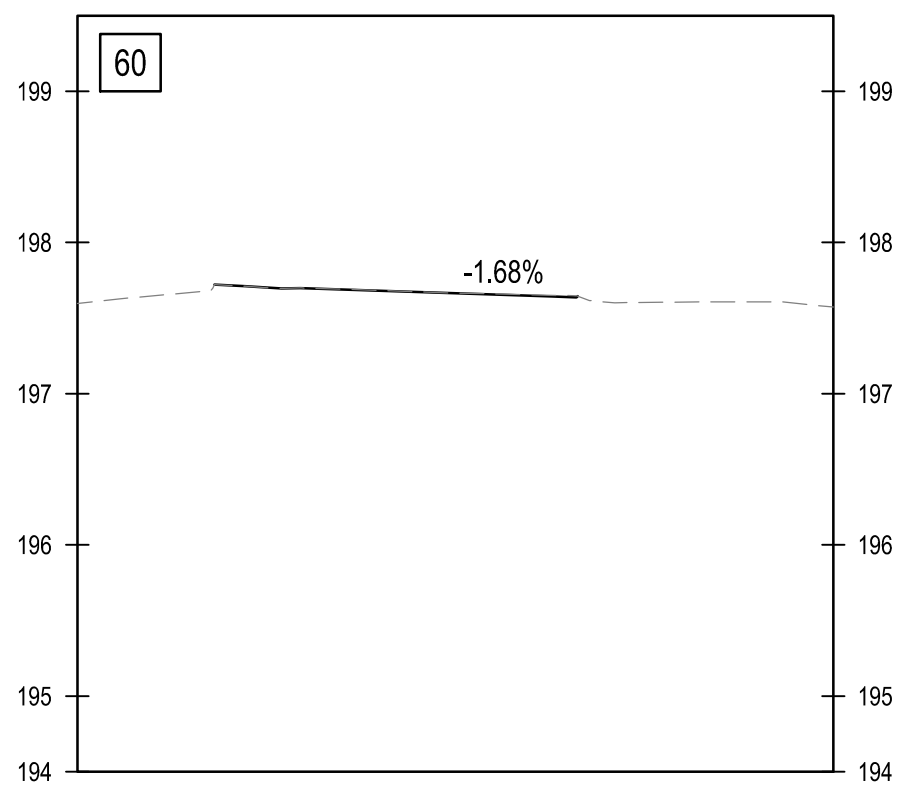
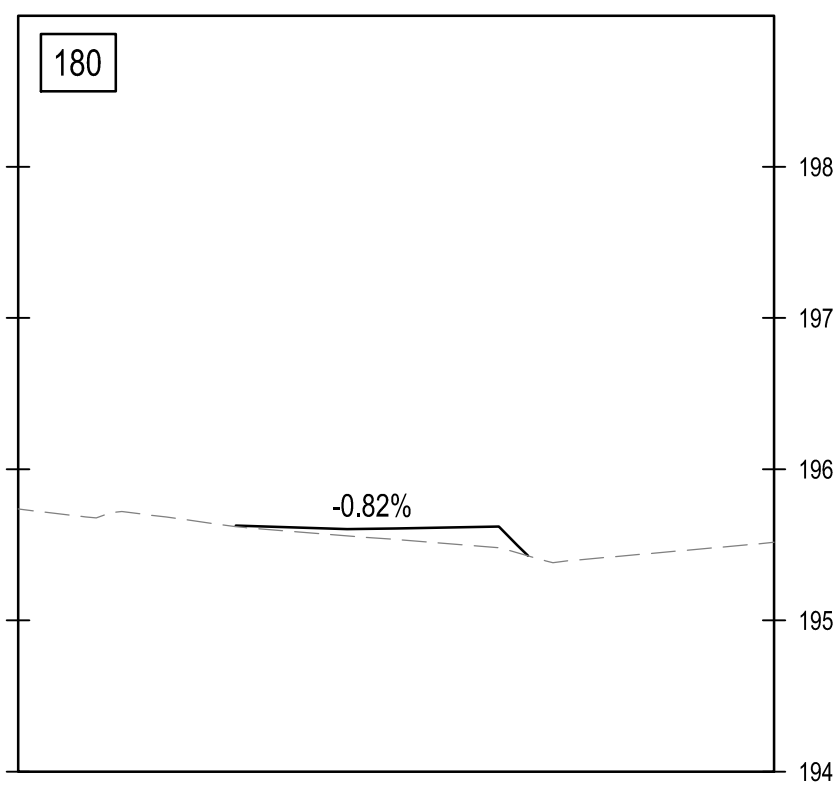
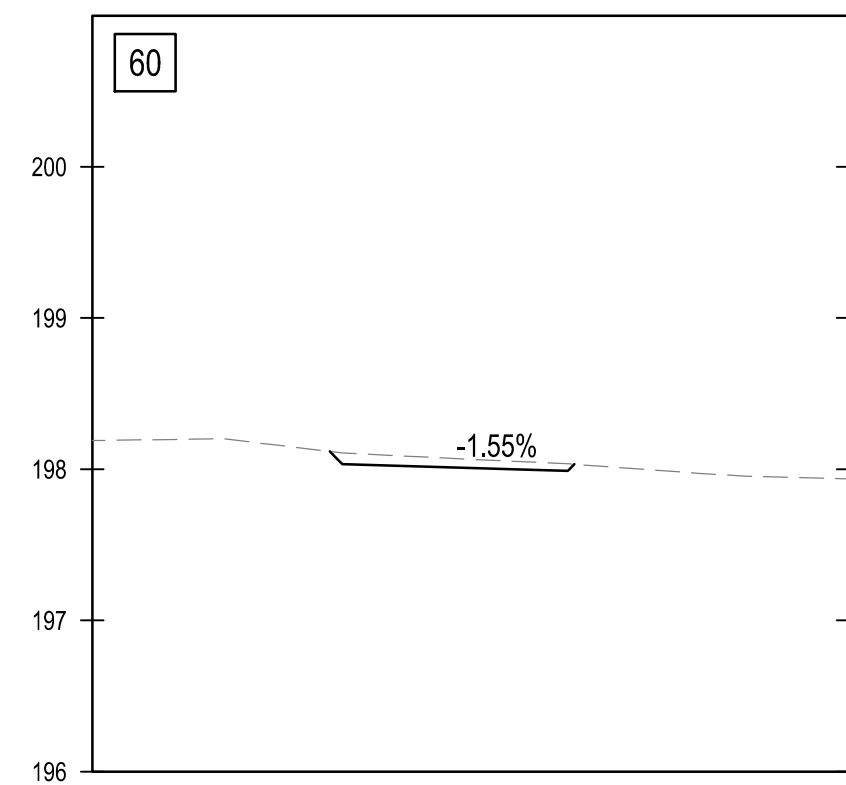
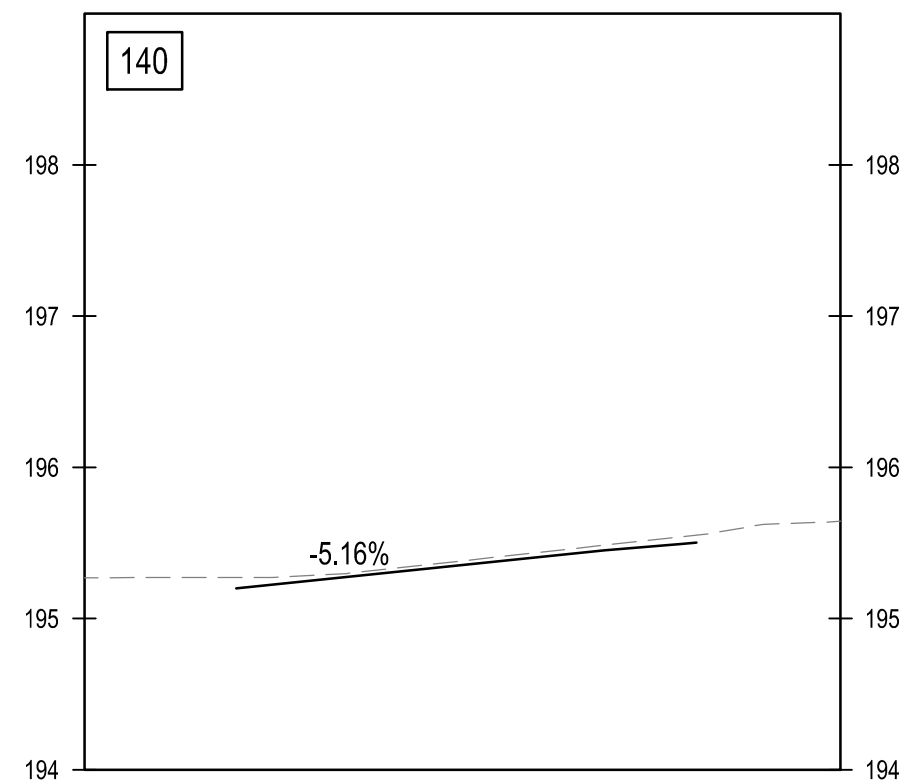
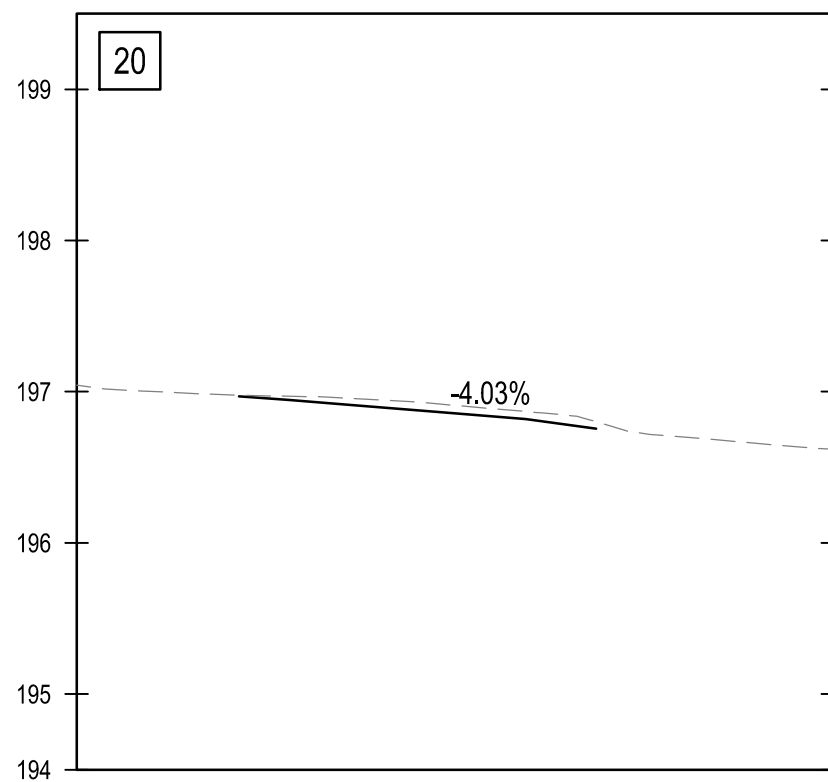
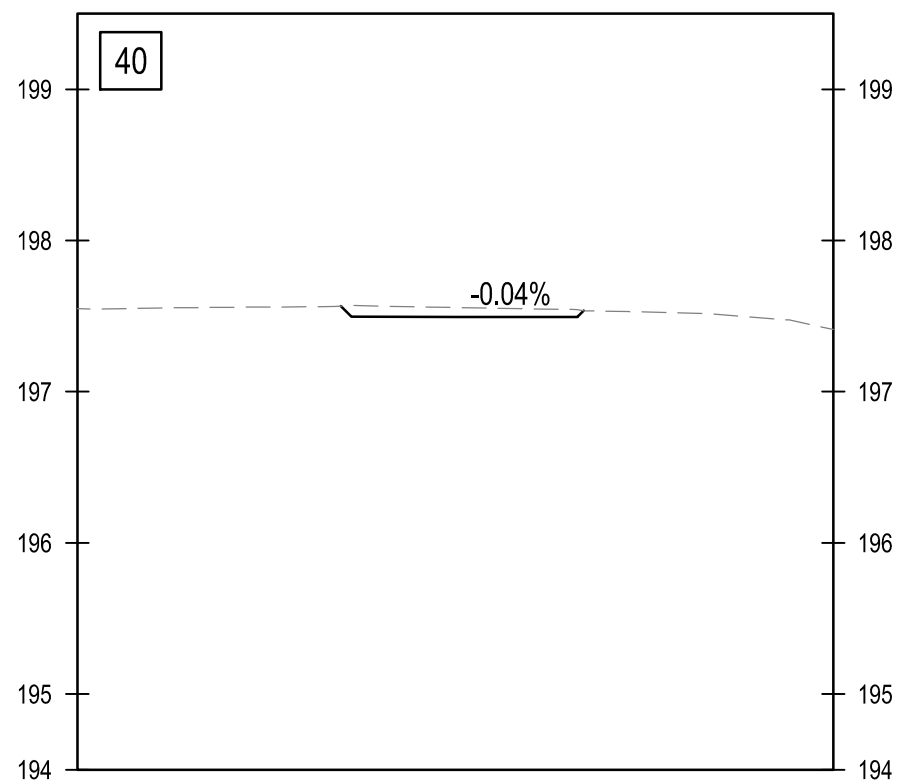
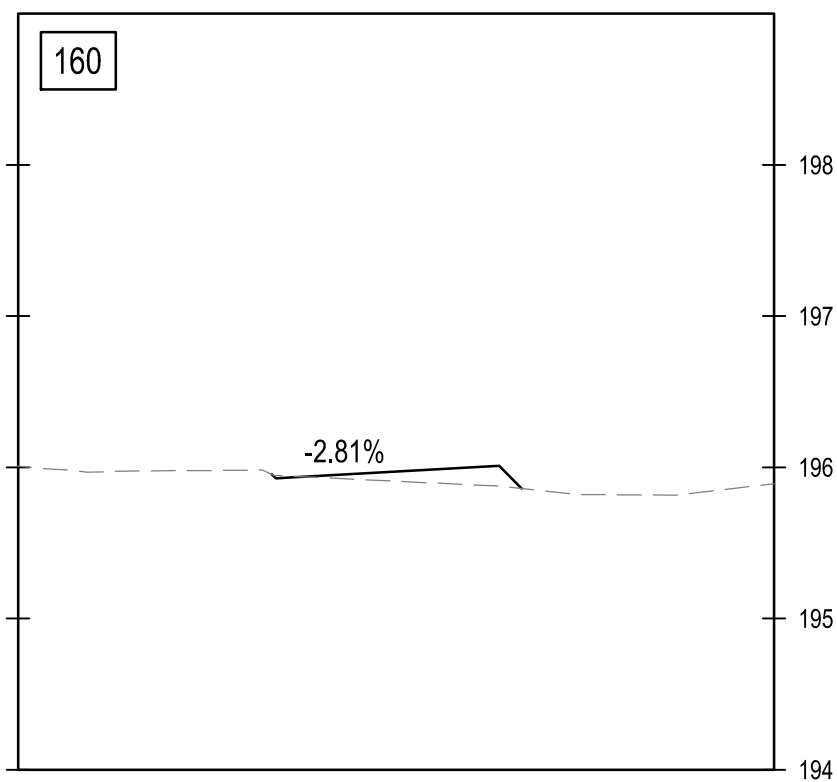
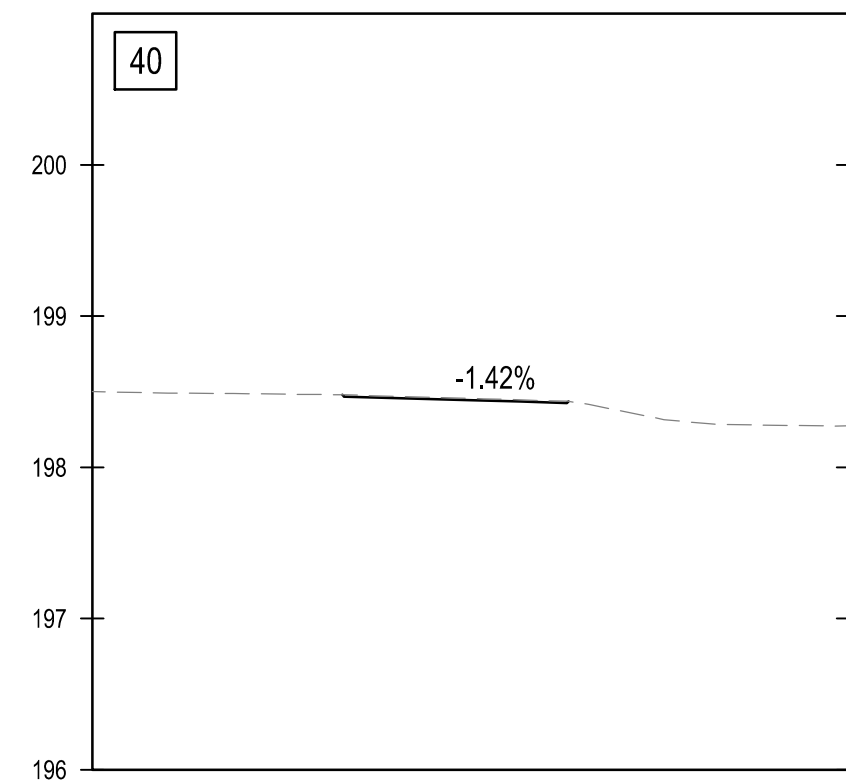
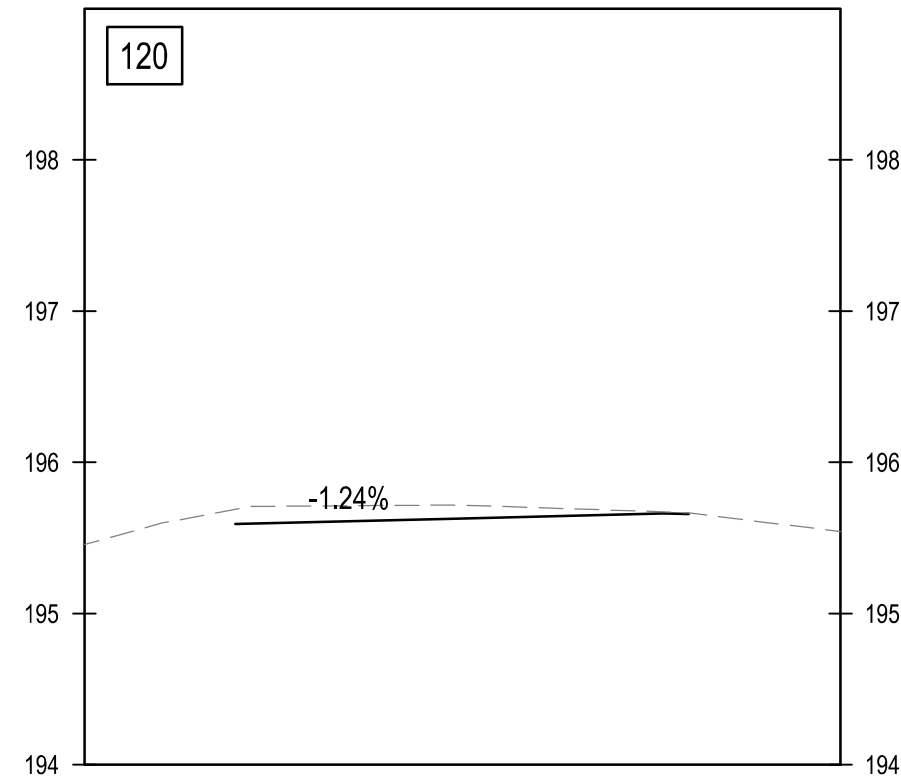
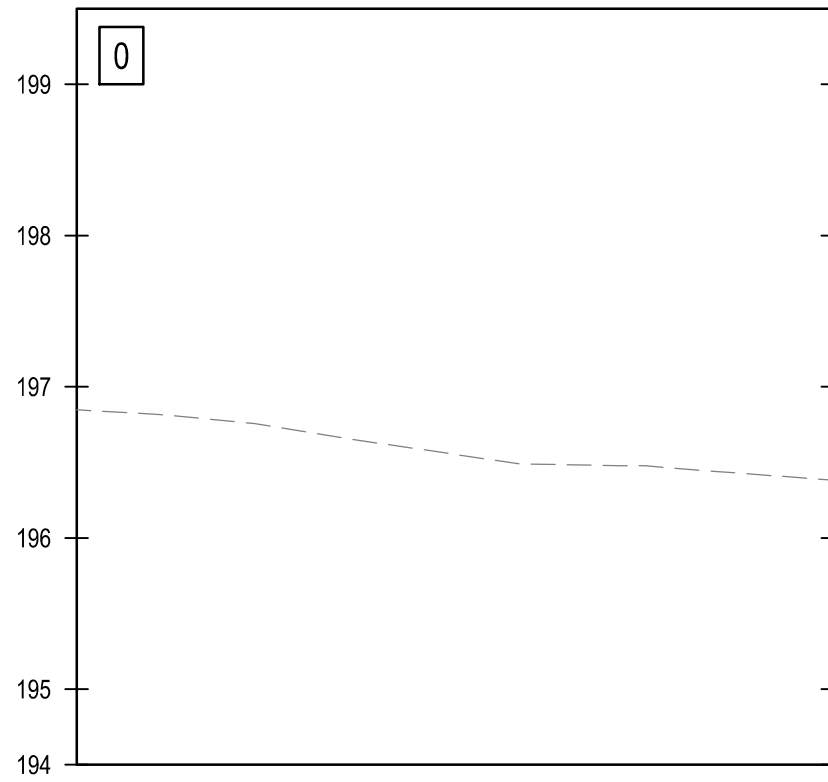
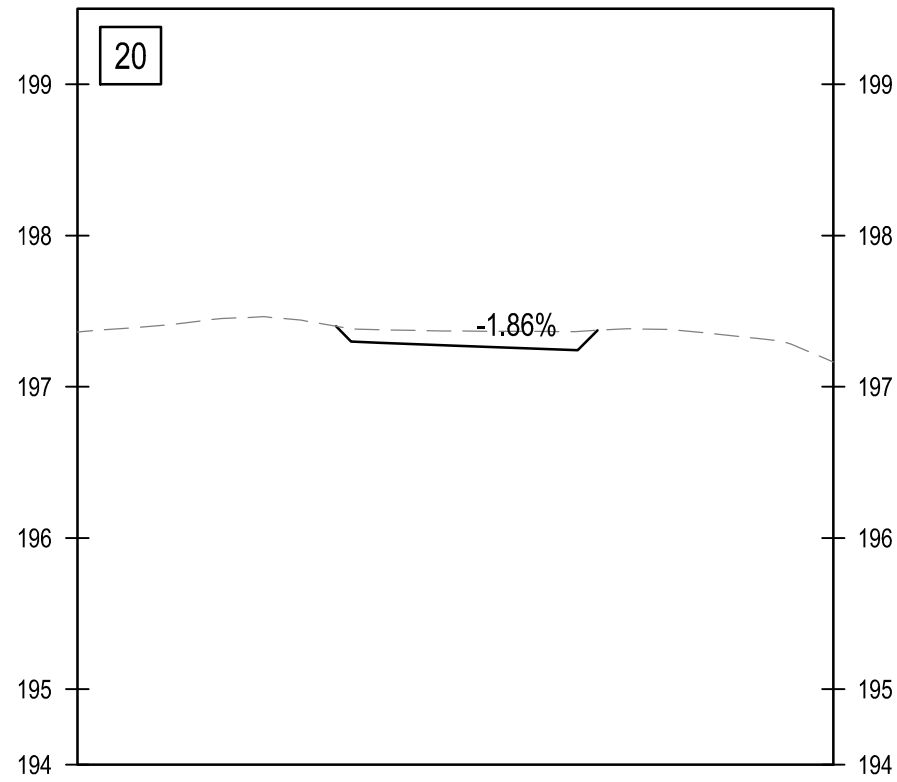
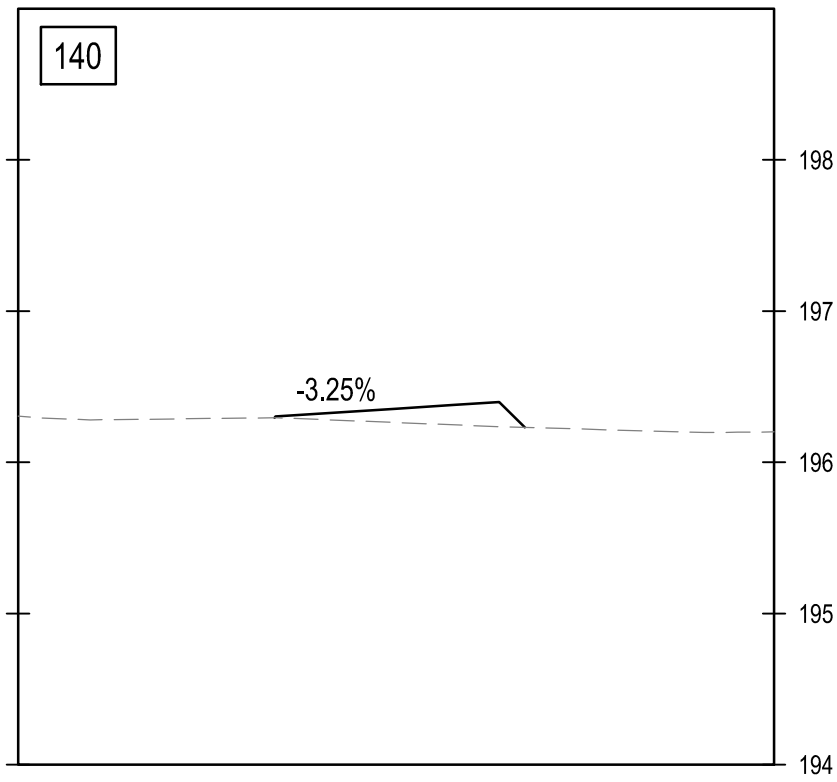
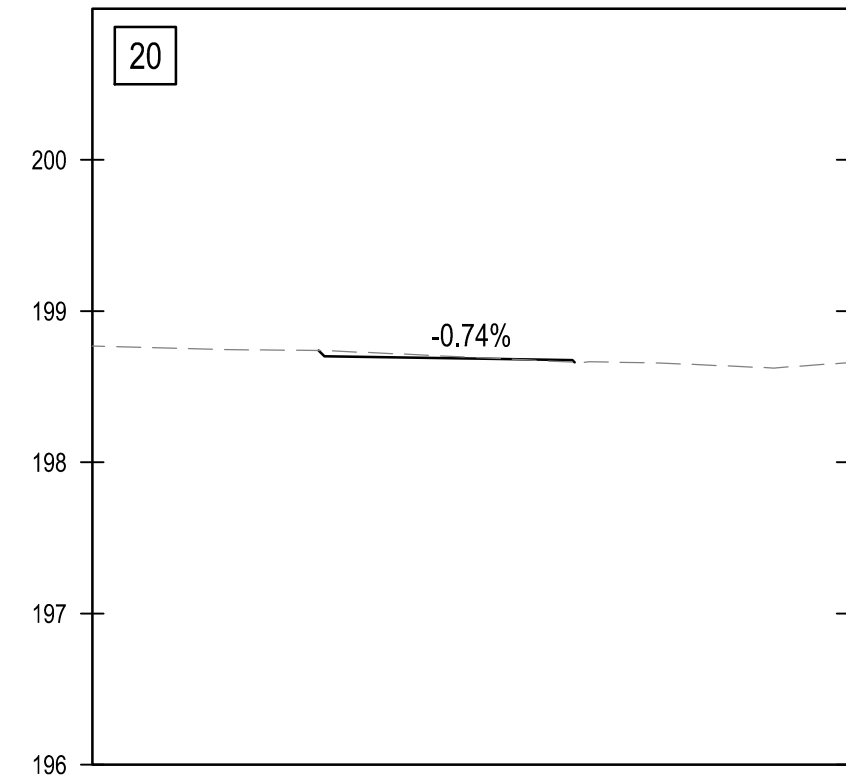


GEORGE MUNICIPALITY

PROJECT TITLE
GWAING WASTE WATER
TREATMENT WORKS UPGRADE

DRAWING TITLE
ROAD CROSS SECTIONS
ROAD 1

SCALE 1 : 100	SHEET SET SHEET 1 OF 1 SHEETS	SHEET SIZE A0
DRAWING No. 1752-RDS-CS-001	REVISION P0	



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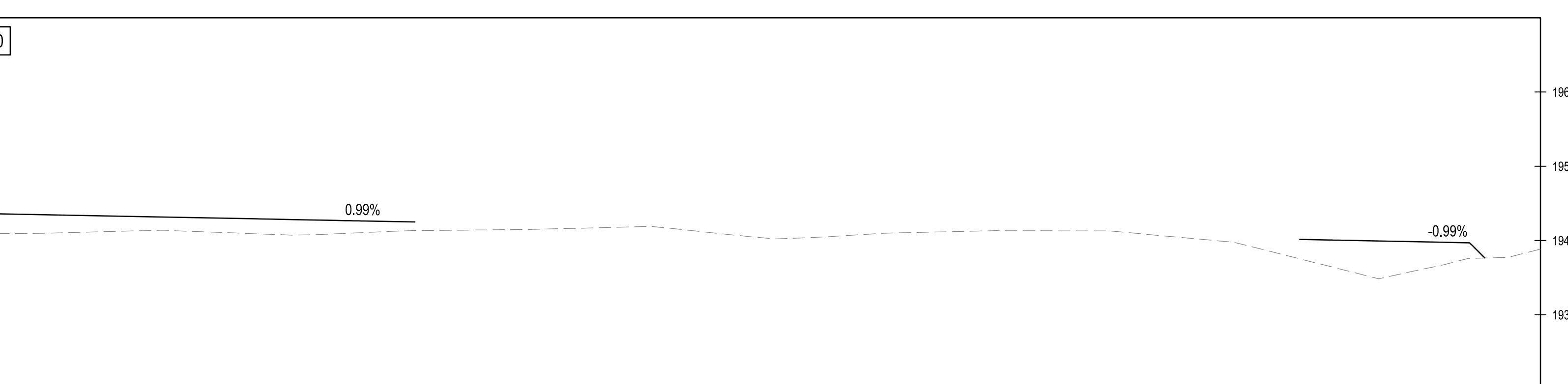
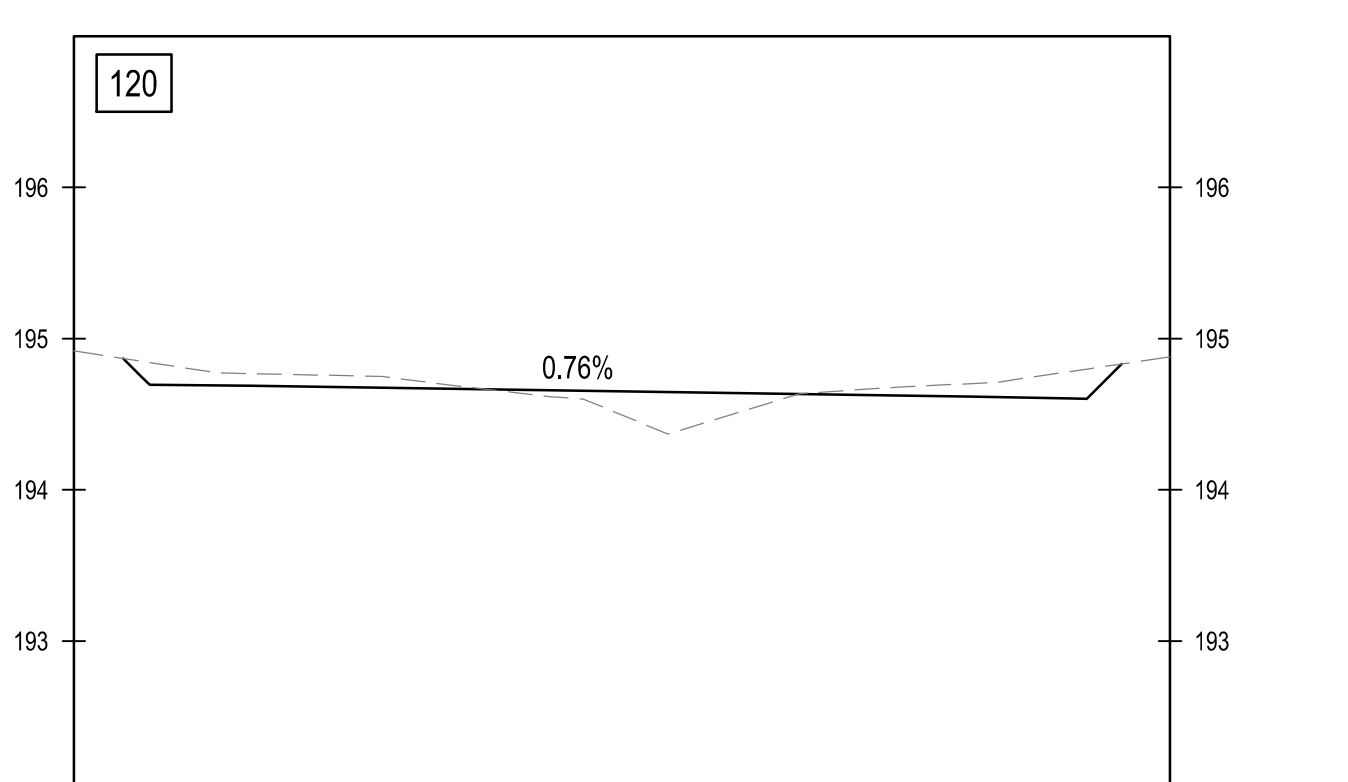
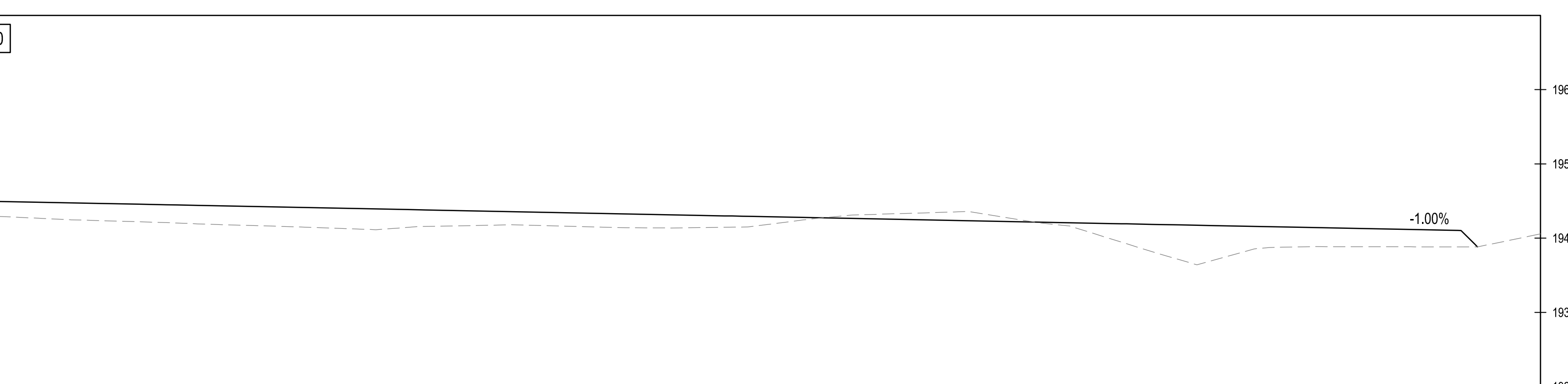
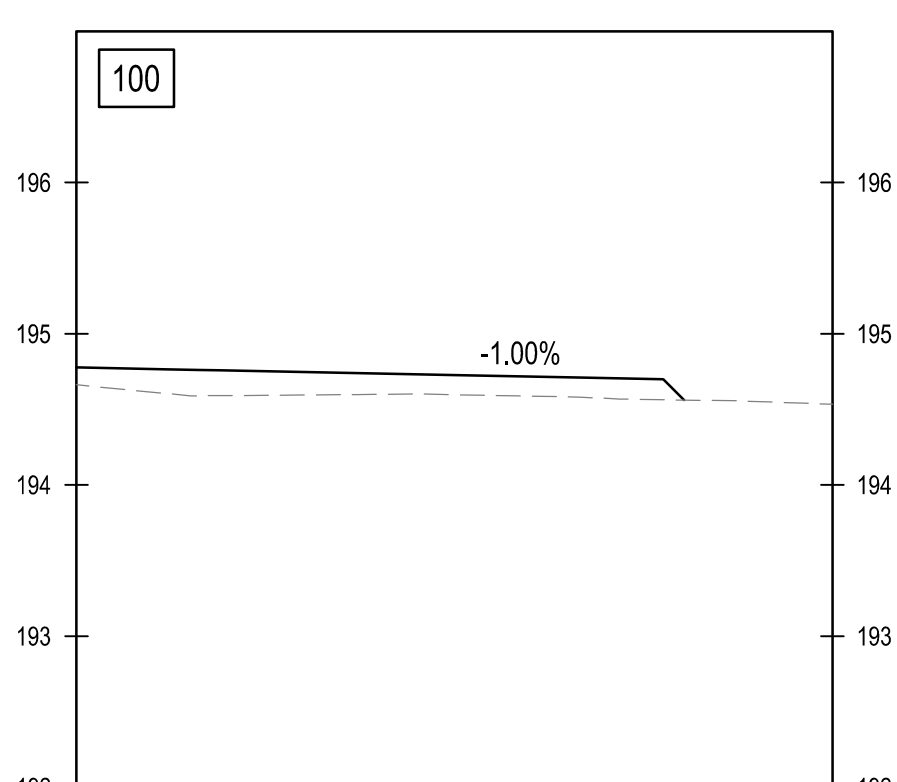
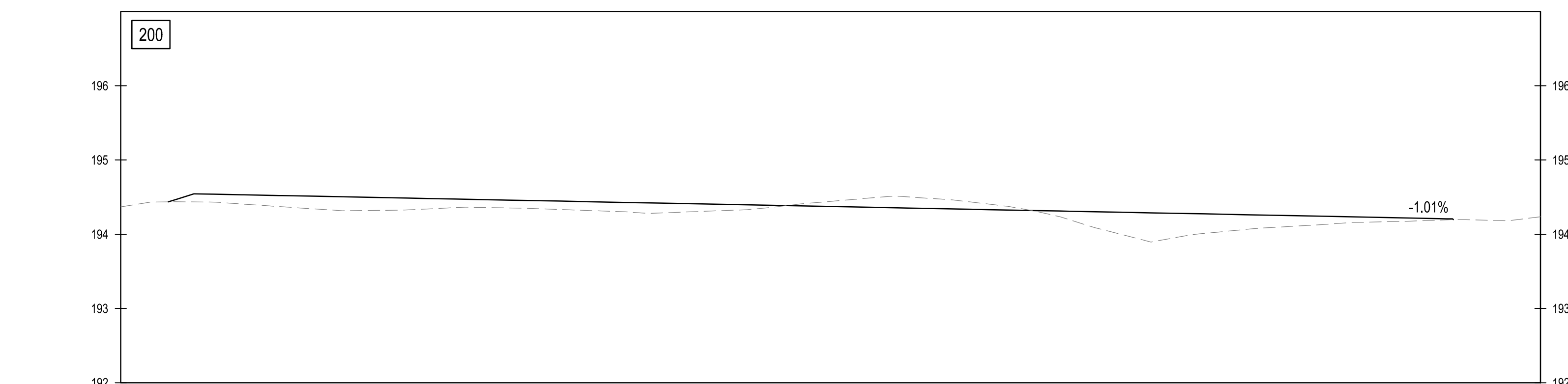
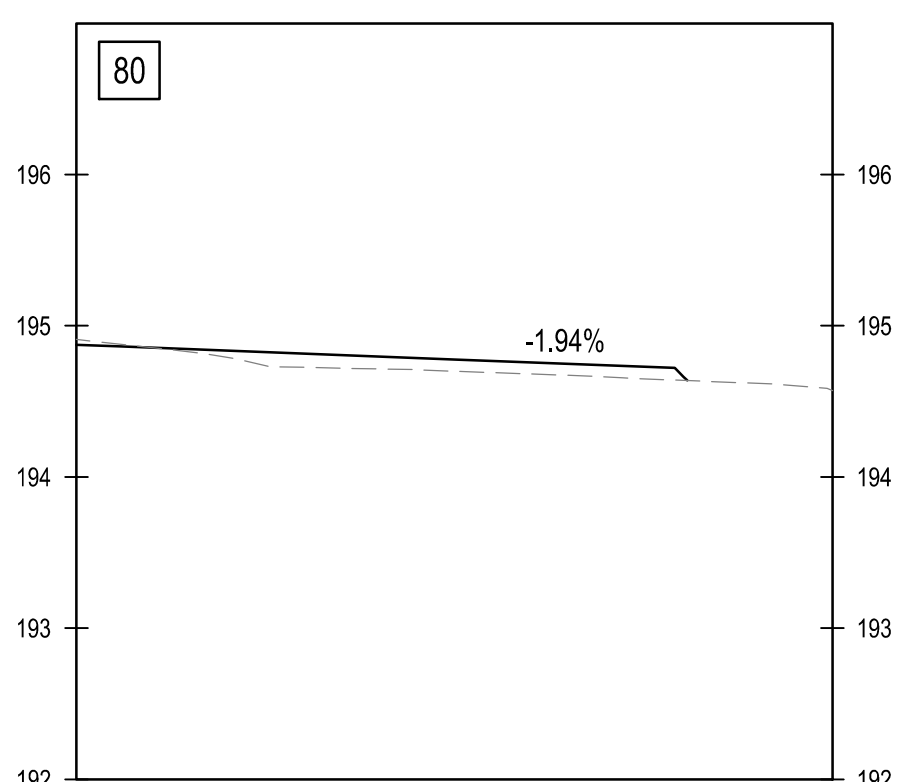
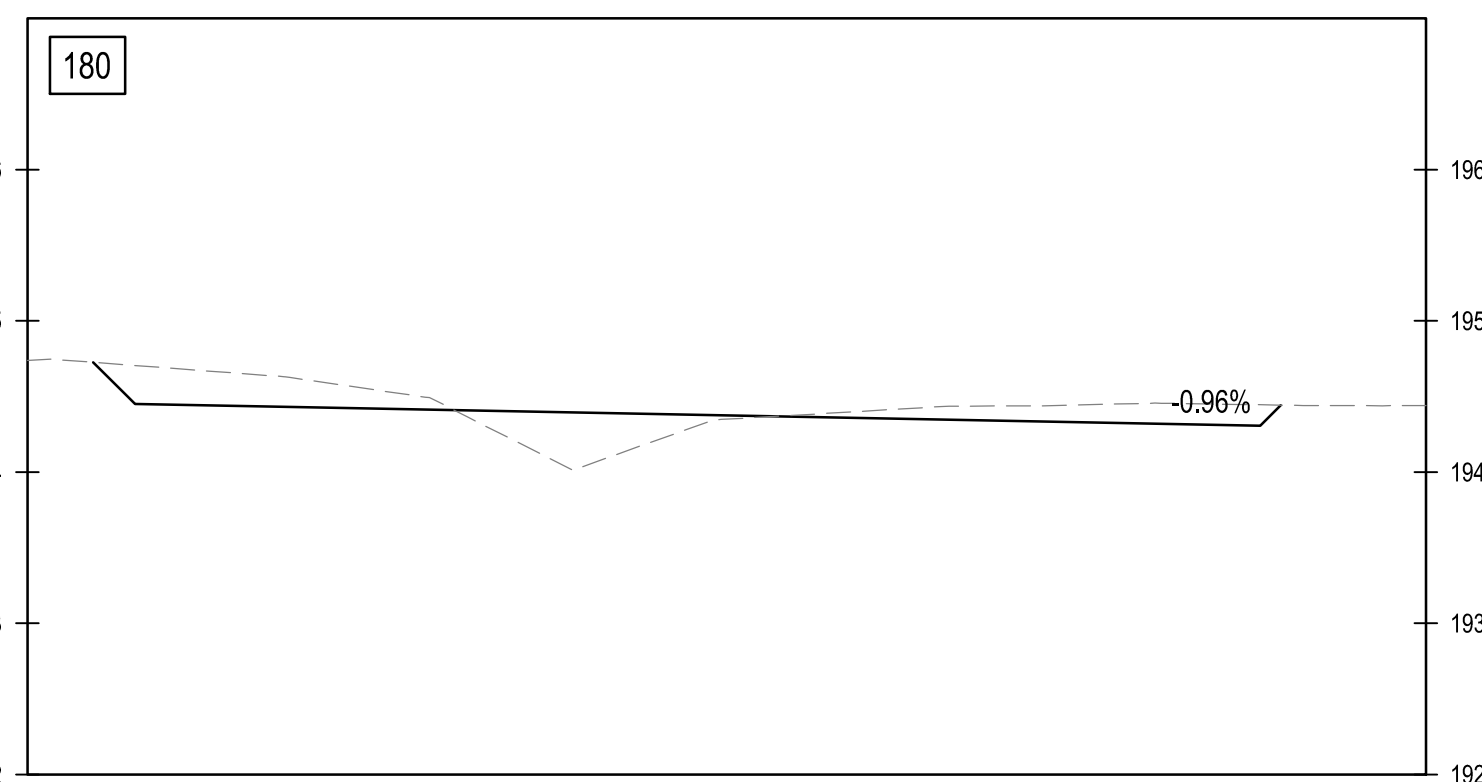
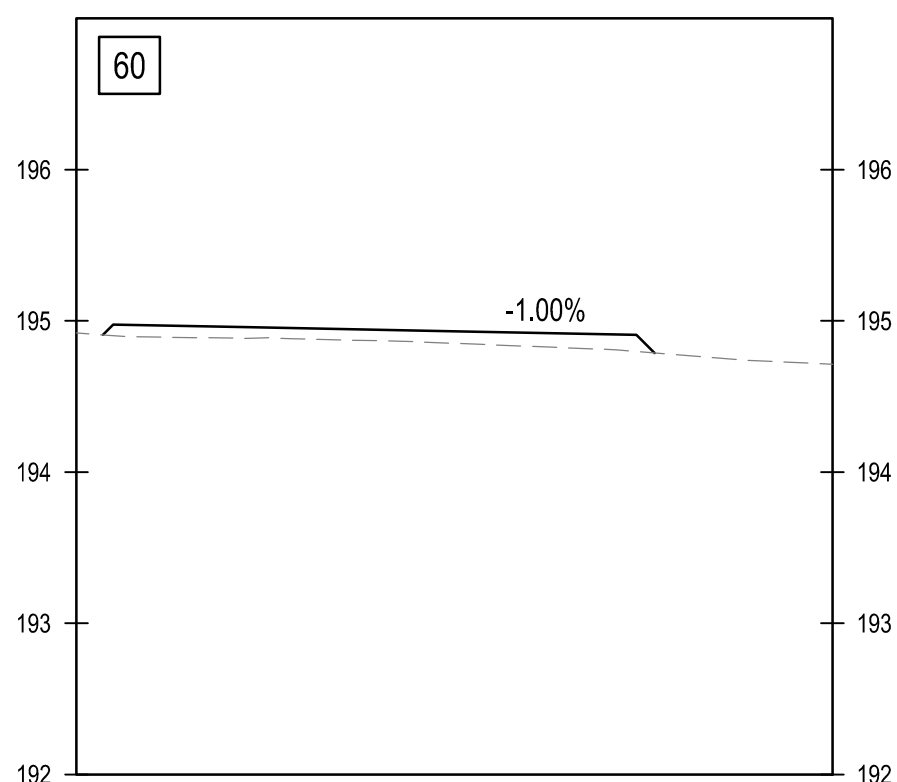
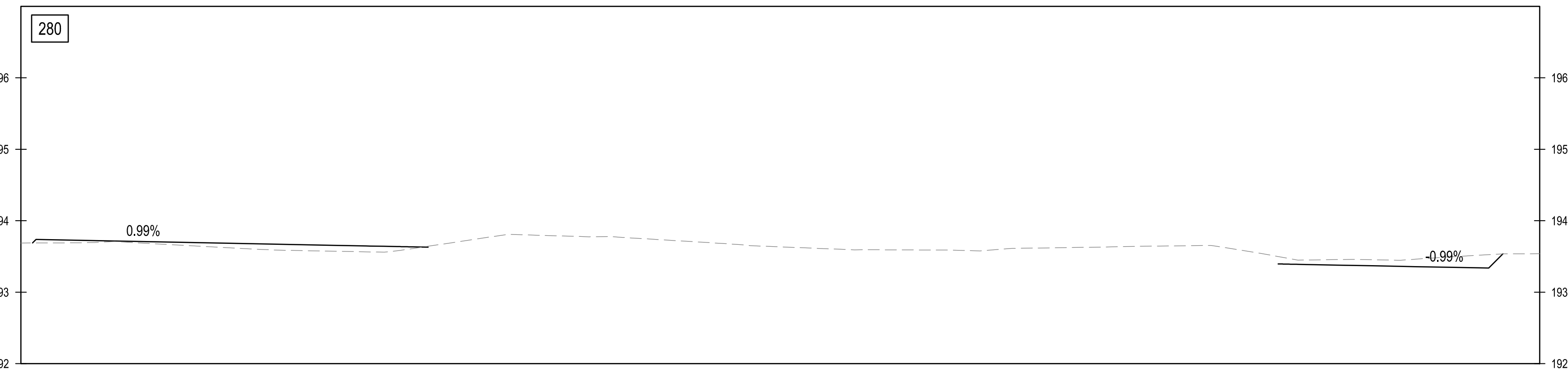
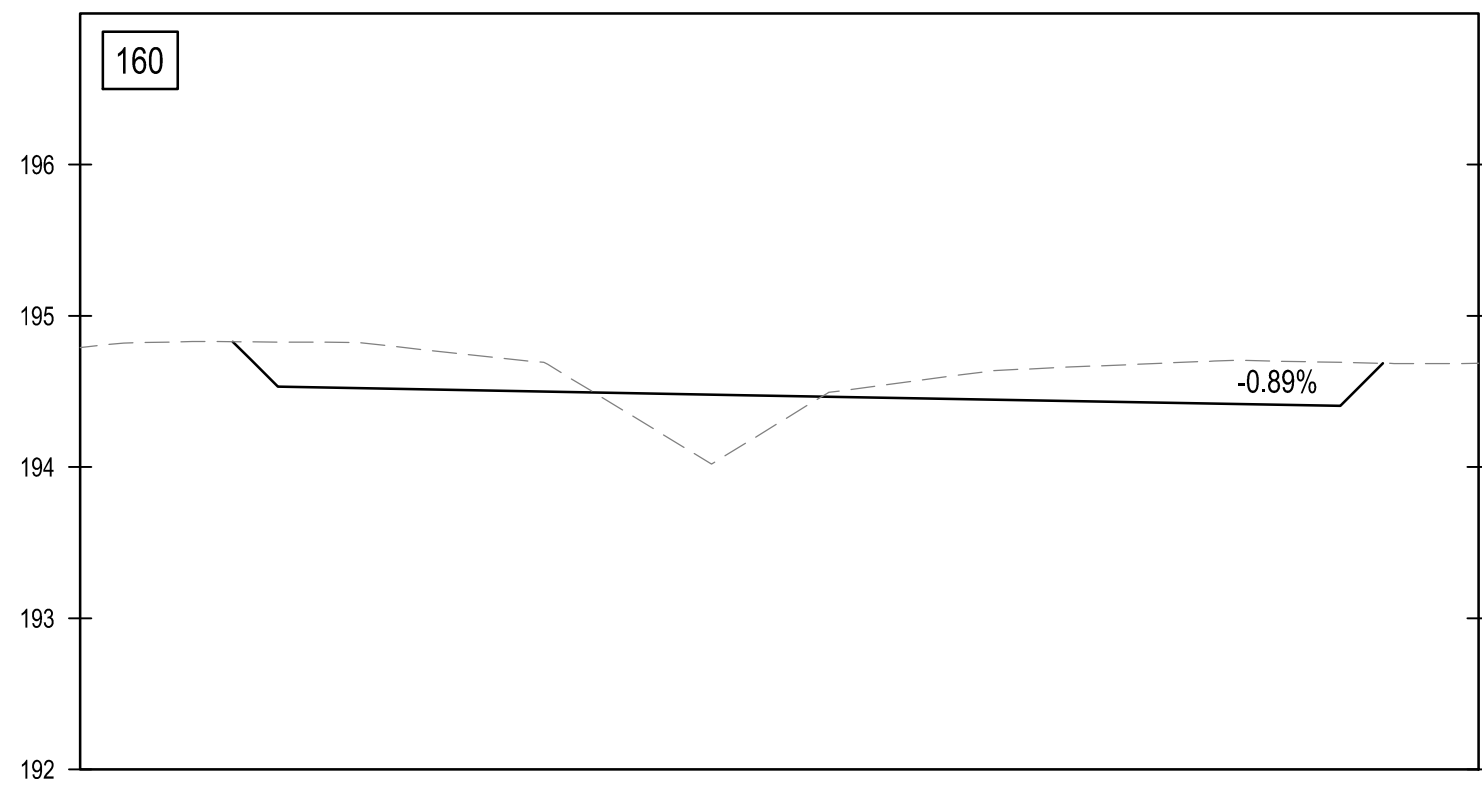
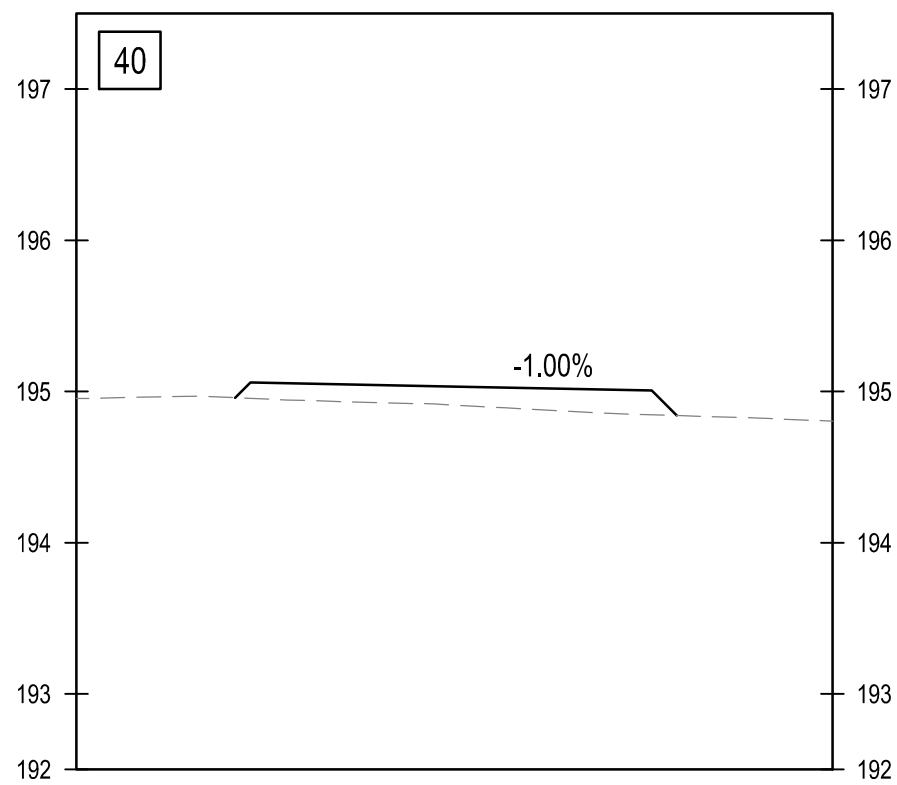
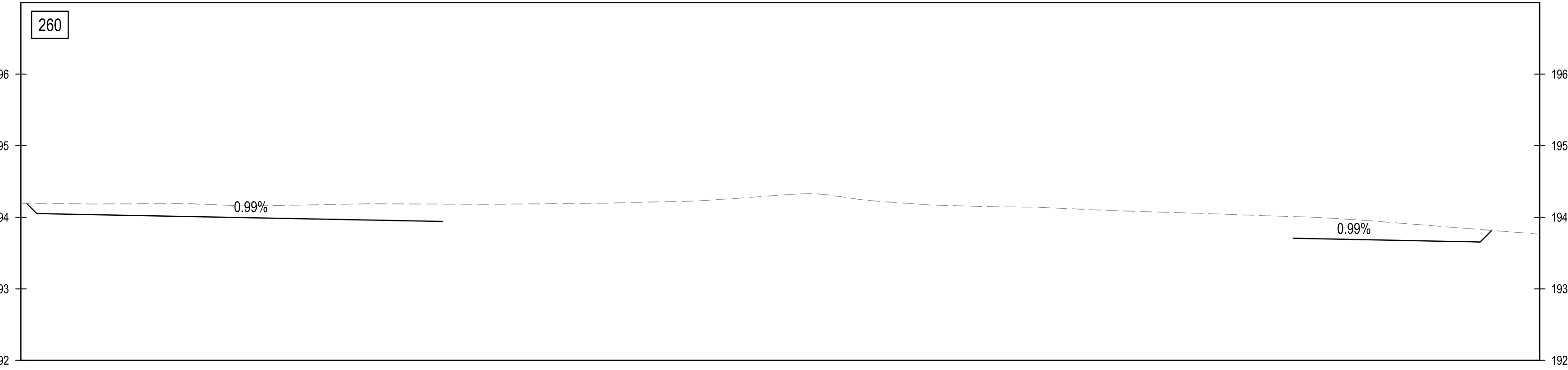
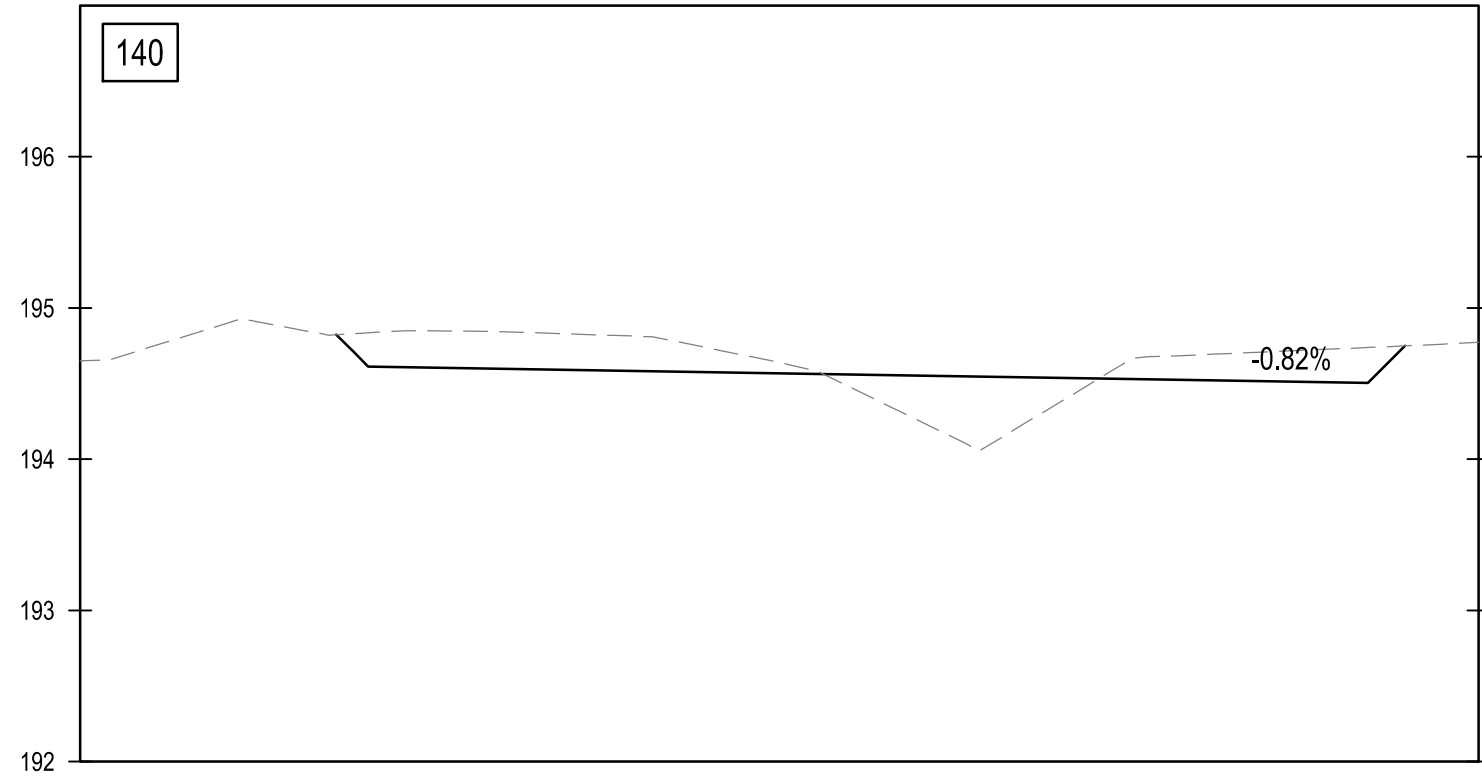
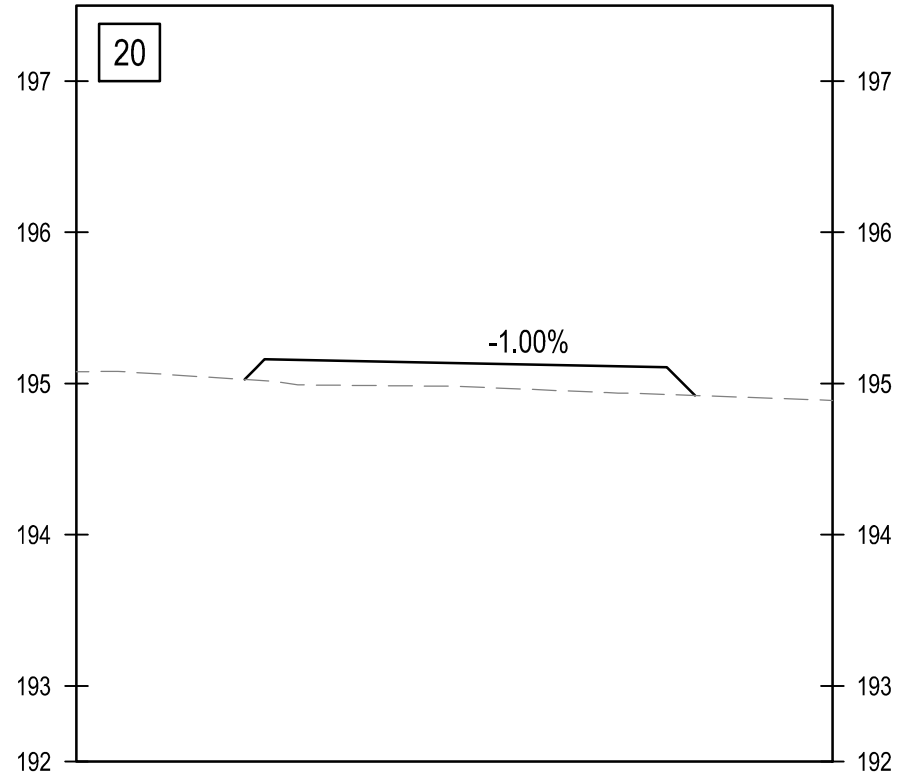


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GEORGE MUNICIPALITY

PROJECT TITLE		
GWAING WASTE WATER TREATMENT WORKS UPGRADE		
DRAWING TITLE		
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SCALE	SHEET SET	SHEET SIZE
1 : 100	SHEET 1 OF 1 SHEETS	A0
DRAWING No.	REVISION	
1752-RDS-CS-002	P0	



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CHECKED	-		-
APPROVED			
	PR REGISTRATION NO.		DATE

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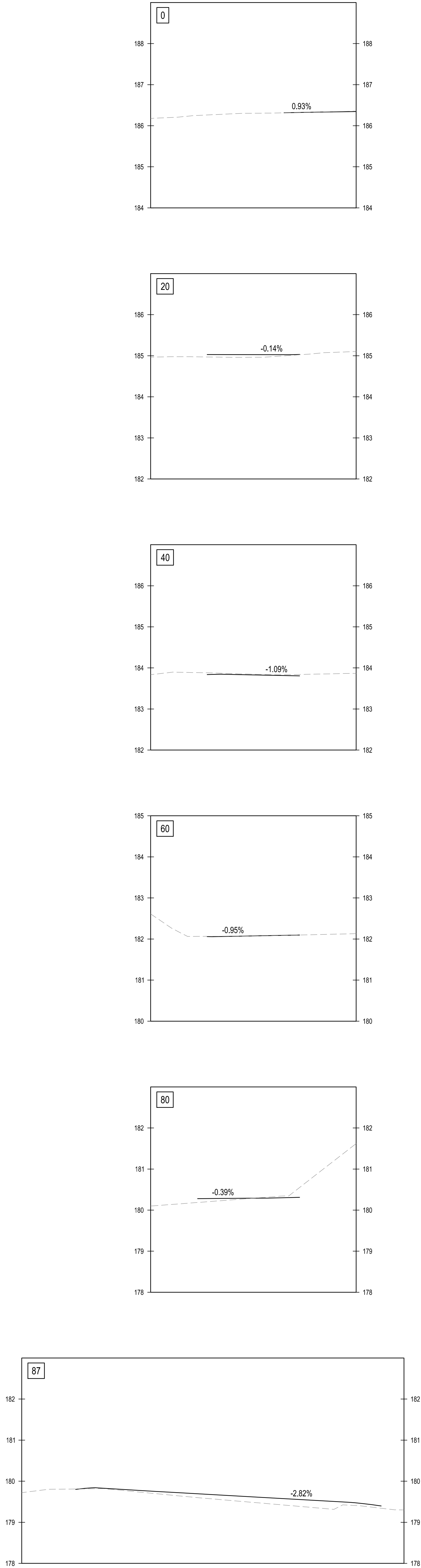


CLIENT



GEORGE
THE CITY FOR ALL REASONS
GEORGE MUNICIPALITY

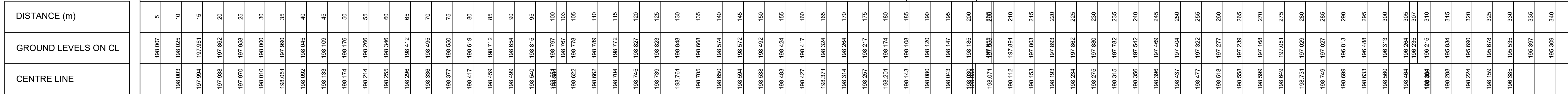
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DRAWING No.	REVISION	
1752-RDS-CS-003	P0	

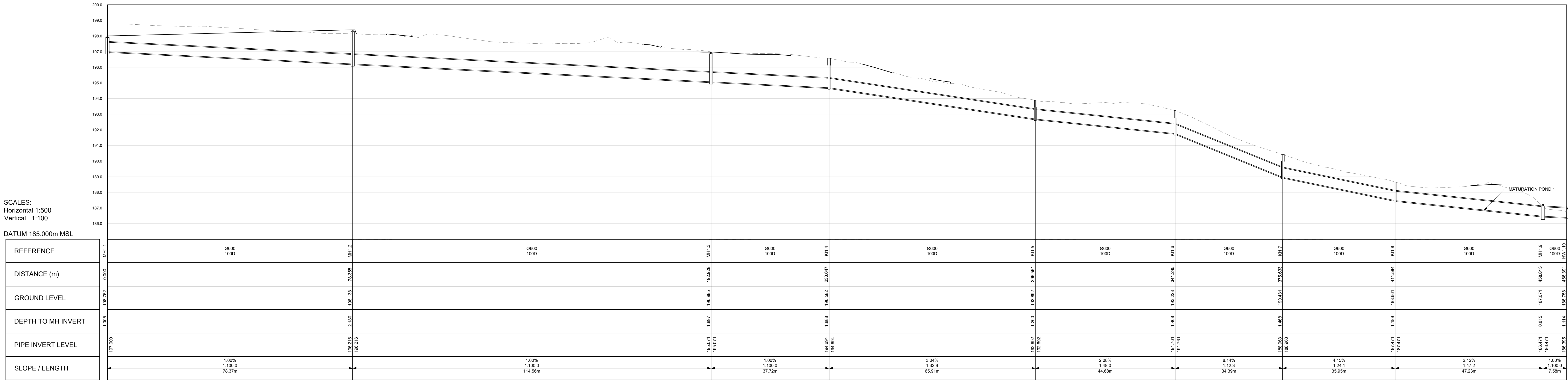


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SURVEYED	-		-
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DESIGNED	-		-
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APPROVED	P/E REGISTRATION NO. DATE:		
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PROJECT TITLE			
GWAING WASTE WATER TREATMENT WORKS UPGRADE			
DRAWING TITLE			
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DRAWING No.			REVISION
1752-RDS-CS-005			P0

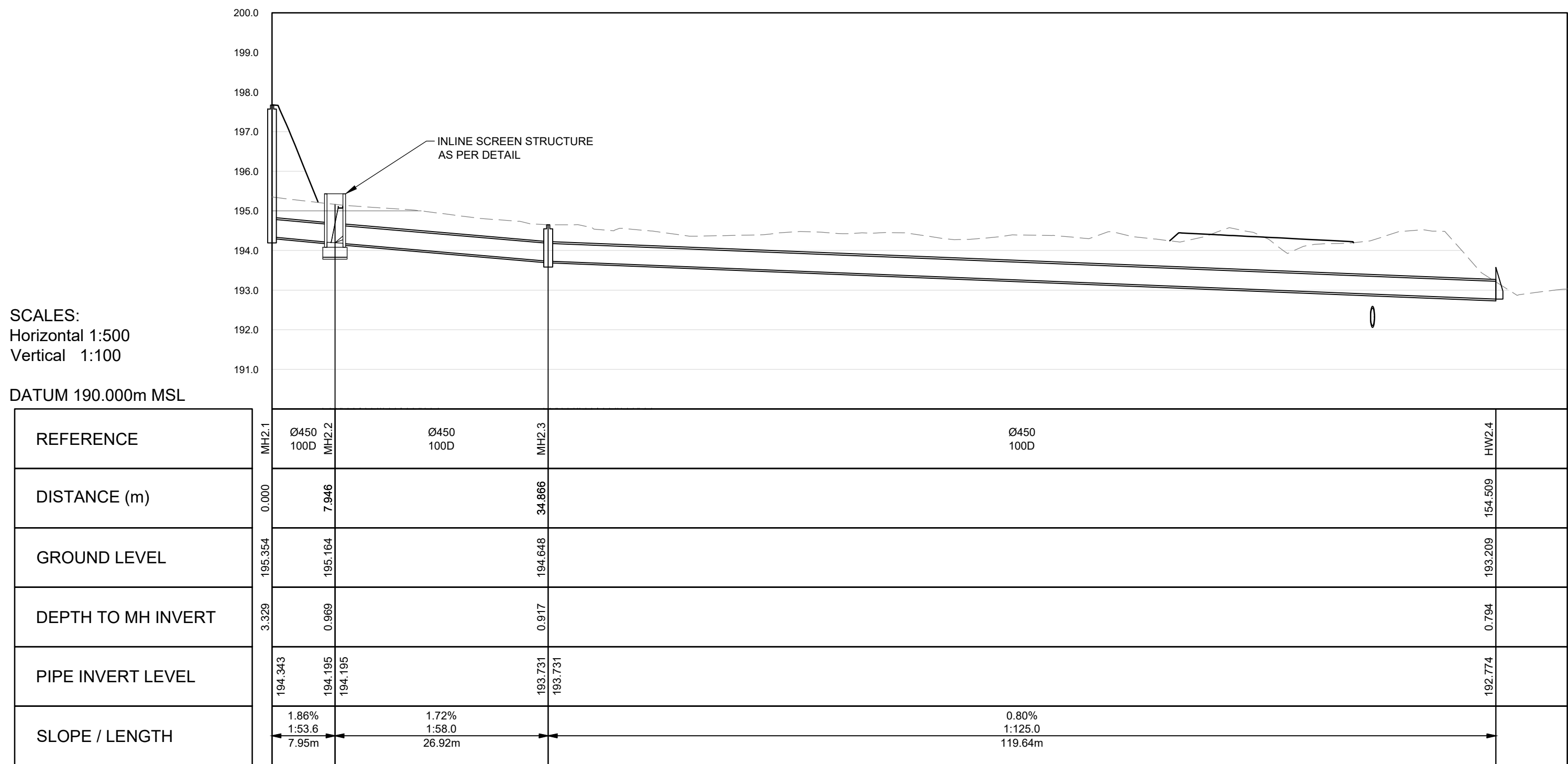
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Vertical 100.000

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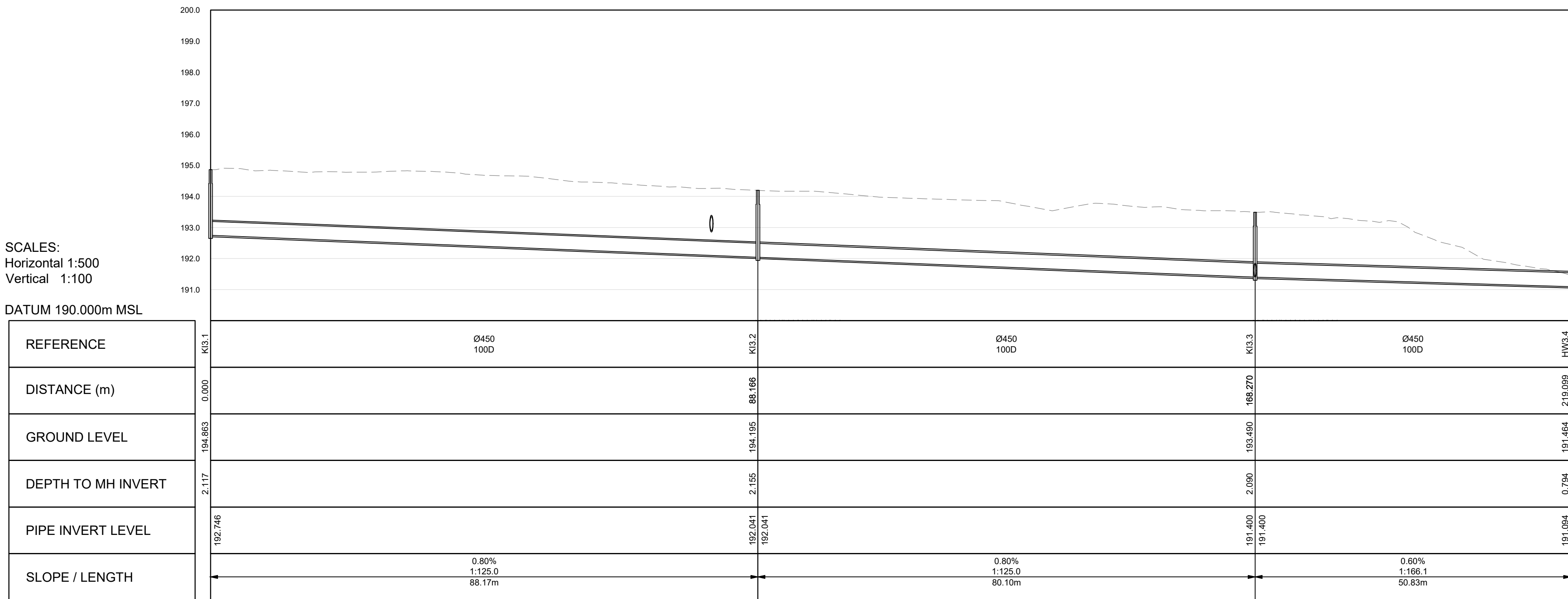




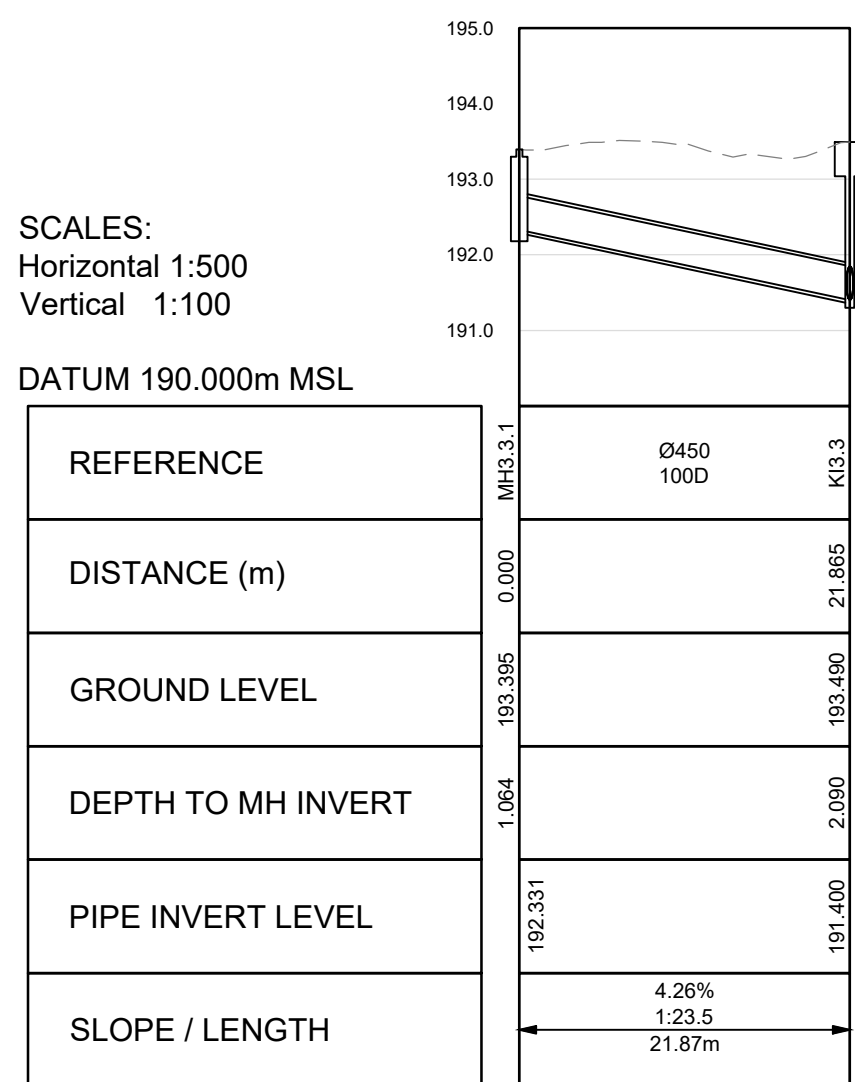
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(FROM NORTH-WESTERN CORNER OF THE BWP TO MATURATION POND 1)



LONGSECTION P-STW-02
FROM 0.000 TO 163.523
(FROM SOUTH-WESTERN CORNER OF THE BWP TO REACTOR B AREA)



LONGSECTION P-STW-03 1
FROM 0.000 TO 219.099
(FROM BLOWER HOUSE ROAD TO REACTOR MODULE C AREA)



LONGSECTION P-STW-03 2
FROM 0.000 TO 21.865
(CONNECTION INTO P-STW-03 1)

ANNEXURE B

CATCHMENT MAP AND HYDRAULIC RESULTS DRAWINGS



DOCUMENT CONTROL SHEET

CLIENT : GEORGE MUNICIPALITY
JOB NO : 1572
PROJECT : GWAING WWTW
TITLE : STORMWATER MANAGEMENT PLAN

Prepared By

Reviewed By

Approved By

ORIGINAL	NAME M SAUNDERS	NAME P DALLAS	NAME P DALLAS
DATE: 12 DECEMBER 2025	SIGNATURE 	SIGNATURE 	SIGNATURE 

REVISION 01	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

REVISION 02	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

REVISION	NAME	NAME	NAME
DATE	SIGNATURE	SIGNATURE	SIGNATURE

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